DOCUMENT RESUME

ED 371 943 SE 054 580

AUTHOR Horton, Robert L.; And Others

TITLE Cycling Back to Nature with Biodegradable Polymers.
INSTITUTION Cooperative State Research Service (DOA), Washington, D.C.; National 4-H Council, Chevy Chase, MD.; National Center for Science Teaching and Learning, Columbus, OH.
REPORT NO ES-0001-01/94-5000
PUB DATE 94
CONTRACT 91-COOP-6107
NOTE 75p.
PUB TYPE Guides - Classroom Use - Teaching Guides (For Teacher) (052)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS Educational Resources; *Environmental Education; Intermediate Grades; Learning Activities; Plastics; *Polymers; *Recycling; Secondary Education; Solid Wastes; Waste Disposal
IDENTIFIERS Biodegradation; Composting; Life Cycles; *Nature; Nitrogen Cycle; Packaging

ABSTRACT

This sourcebook, for use with groups of up to 25 young people ages 10 and up, is designed to stimulate a sense of environmental stewardship for the planet through group discussion, role playing, experimentation, demonstration, and simulation. Lessons that stand alone or can be used in sequence require common materials and little preparation, making them useful for volunteer leaders with limited resources. The activities are organized in nine sections that illustrate the interlocking and overlapping aspects of nature's cycles. The activities in the sections: (1) introduce the group to four natural cycles: water, carbon dioxide, nitrogen, and oxygen; (2) review interaction between producers, consumers, and decomposers within the natural cycles; (3) explore the meaning and production of plastics; (4) talk about the presence of plastic packaging in the environment; (5) help the group see why biodegradable polymers are an important breakthrough; (6) help the group see that composting is nature's way of recycling; (7) explore the need to recycle traditional plastics; (8) help the group focus on the range of possibilities for packaging with biodegradable polymers; and (9) help the group explore ways to increase public awareness about biodegradable polymers while emphasizing the need to reuse, reduce, and recycle. Seven appendices contain information and activities about earth cycles, landfills, composting, labeling, packaging, and letter writing. (MDH)

Recycling Back to Nature

with Biodegradable Polymers

This publication is a product of the National 4-H Council in cooperation with the United States Department of Agriculture Cooperative States Research Service, the Advisory Technical Committee on Biodegradable Polymers from Renewable Resources and the National Center for Science Teaching and Learning.

Contents

Cycling Back to Nature with Biodegradable Polymers

Coordinated by

Maria T. Castro, M.P.A., Program Initiative Specialist, National 4-H Council

Written by

Robert L. Horton, Ph.D., Extension Specialist, 4-H Science Education, Ohio State University Extension

Joe E. Heimlich, Ph.D , Extension Specialist, Community and Natural Resource Development, Ohio State University Extension

James R. Hollyer, M.S., Junior Researcher, Department of Agricultural and Resource Economics, University of Hawaii at Manoa

Editing and Design by

Liz Cutler, M.A., Associate Editor, 4-H, Ohio State University Extension

Paine, Bluett, Paine, Inc., Design and Illustration Studio, Calverton, Maryland

Amy Bernstein, President, Gavroche Marketing, Baltimore, Maryland

Cycling Back To Nature

An environmental sourcebook of activities addressing the environmental influence of natural products, manufactured products and by-products on the earth's natural cycles

Welcome

For a long time, children and adults have been told *what* to think about certain issues, rather than *how* to think about them. These days, however, it is becoming more and more important to teach the hows and whys. Learning and refining critical-thinking skills will help society in many ways. But it will take practice, perseverance and the right tools to mobilize people with these skills. With this guide, we hope to create a learning environment where critical thinking can occur while aspects of the environment are being explored.

The 4-H Environmental Stewardship program hopes to foster a sense of responsibility for the future by teaching young people how to make informed decisions about available resources. These resources include people, land, water, air, trees and so forth. One specific issue is the reduction of waste and, more specifically, packaging. This is an area of great debate. There is no one solution, rather, many solutions that involve compromise. In this leader's guide we hope to provide an opportunity for leaders and educators to explore these issues and then pass on their experience to others. In order to explore some of these issues, we have tried very hard to blend current facts with fun and informative hands-on examples. The result is a resource guide that differs from basic science textbooks in that it is highly interactive and emphasizes hands-on experimentation and discussion over lectures.

Outline of Book

This leader's guide is organized so, like nature's cycles, concepts are interlocking and overlapping. This figure gives a pictorial representation of the flow of this work.

About the Lessons

This sourcebook — for use with groups of up to 25 young people, ages 10 and up — is designed to stimulate a sense of environmental stewardship for the planet through group discussion, role playing, experimentation, demonstration and simulation. Each lesson requires fairly common materials and not much preparation time, making it ideal for volunteer leaders with limited resources.

The lessons may be used on a stand-alone basis or in sequence as a comprehensive unit of study. Since the lessons vary in complexity and sophistication, you may pick and choose among them to suit students' abilities. When preparing each lesson, review the Background, Bio-Note and Activity sections provided. Gather the necessary materials and practice the experiments and activities beforehand. (Feel free to improvise if all the suggested materials are not available.)

Next, familiarize yourself with the Discussion and Processing sections provided. A proper discussion of an activity beforehand will help students prepare for the learning that follows. Once an activity is completed, allow time for processing. Use the guiding questions provided to help students relate what they observed and experienced to real life situations. When processing an activity, try not to focus on answers being "right" or "wrong." Rather, accept all answers as possible solutions. Then, help the group see why a particular answer may be more appropriate than others, especially if the answer you were looking for was not given.

Lessons should last at least one hour and include a minimum of two to three activities. Time permitting, you may wish to explore some of the Digging Deeper activities. Likewise, if you are providing a series of lessons, consider doing some of the Going Beyond activities. They are designed to provide a bridge between the lessons.

Finally, before undertaking any of these lessons, be sure that you are comfortably familiar with the underlying scientific principals discussed. Read up on recycling, composting, and waste management beforehand.

Recycle this Workbook!

Save the outer wrapping this workbook came in for use in experiments in Lessons 5 and 6. Also be sure to recycle as much material from experiments as possible.

Teaching Outline

The following is a recommended outline for conducting a series of lessons using the *Cycling Back to Nature* curriculum. As you begin your planning, refer to pages 2 and 3 for an overview of the scope and sequence of this curriculum.

Review of Last Session — Be sure to review what was learned at the last session. This will help members have a common starting place for the current session and lead into new information.

Introduce New Knowledge — Rely heavily on showing rather than telling. Refer to the activities in each lesson or use your own to get your message across.

Summarize Learning — Have the group talk about what they learned and what they liked doing. Focus on the positive, especially when things don't work out as you planned.

Bring Closure to the Session — If possible, end with recreation and refreshments. Also be sure to provide an overview of what will be covered during the next session. Try building excitement for what's to come by giving the group a problem to solve or maybe even a question to be answered.

1 Earth's Natural Cycles

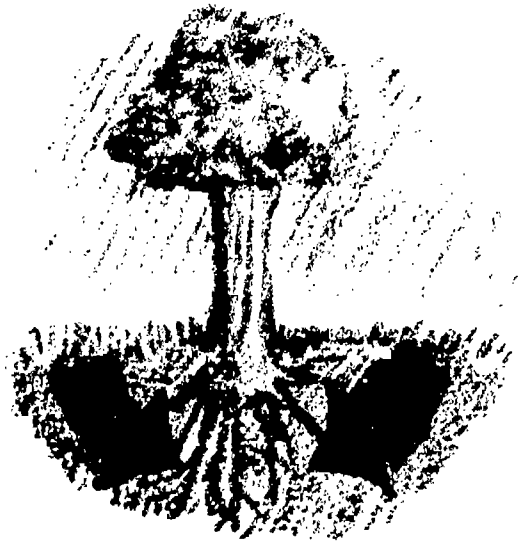
All living things are found within a relatively thin layer on or near the surface of the earth. Apart from the sun's energy, all their needs are supplied by a finite amount of earth's resources cycling within this layer. If the water, oxygen and other elements vital for life were only used once, they would soon run out. This is why many of nature's processes work in cycles. There is a constant cycling of the elements among air, earth and water, ensuring that all living things are able to live and grow.

One of the most important elements in these cycles is oxygen, which exists freely as a gas in the atmosphere, and is also an essential part of both the water and carbon cycles. Carbon and nitrogen are also vital. Other elements of importance include the minerals phosphorus, sulphur and calcium, and trace elements, like iron and zinc, that are needed in smaller quantities. These all supply energy for life and are important in the process of growth and the constant renewal of living things.

Objectives

The students will learn about:

- the differences between the four natural cycles
- how the natural cycles operate
- the relationship among the cycles



Bio-Note

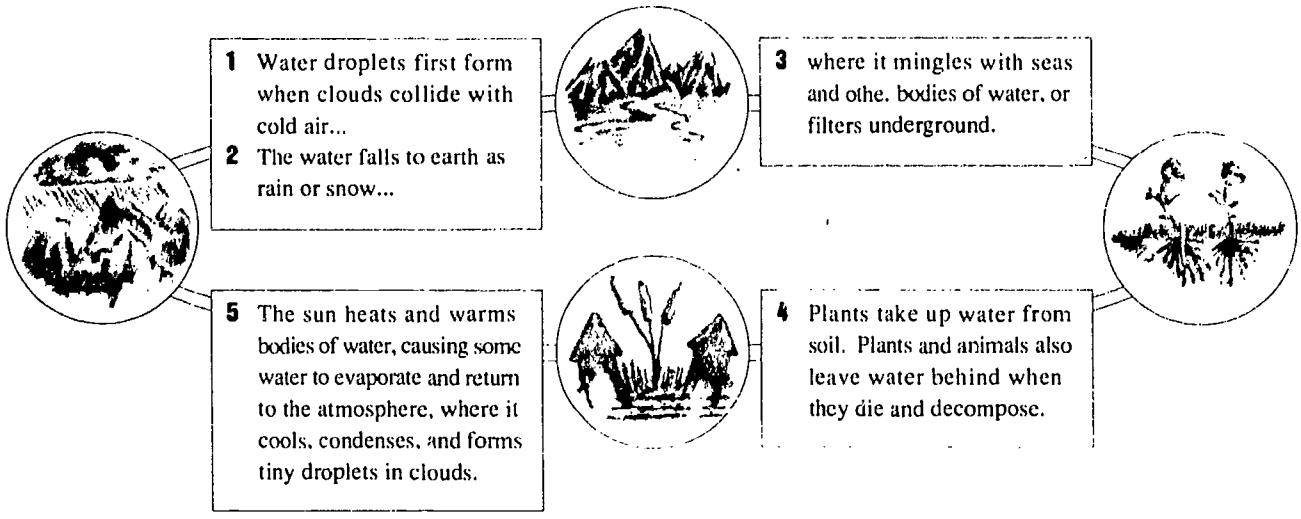
See pages 6-8 for illustrations of earth's natural cycles

Natural Cycles

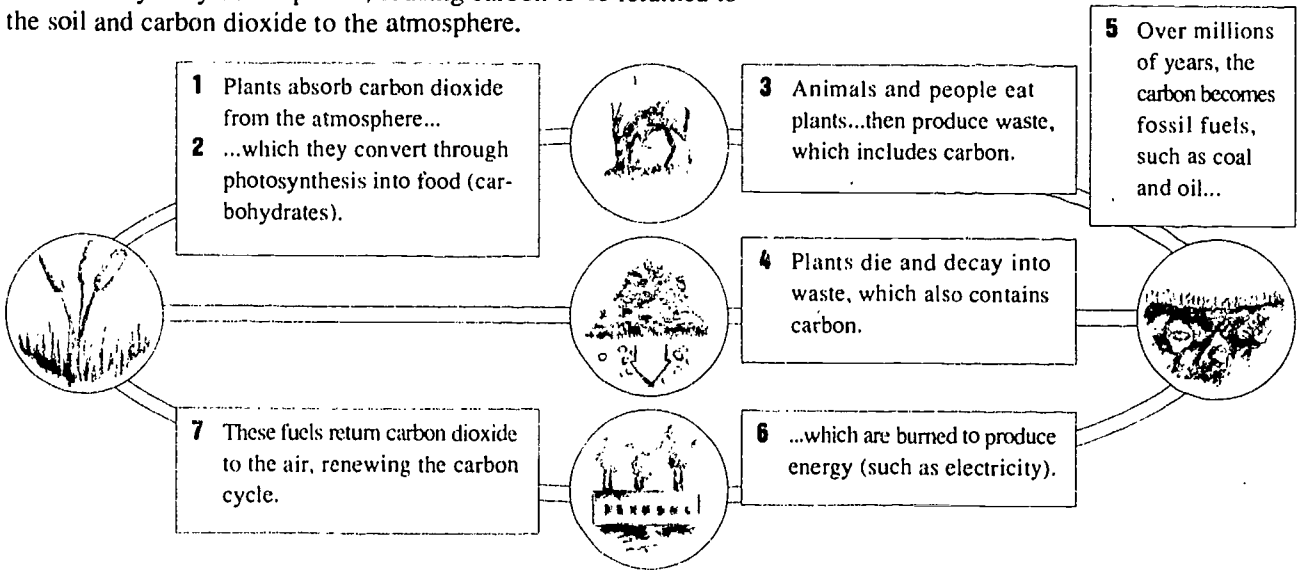
Water Cycle — Water is an essential resource, making up almost 75 percent of all living things. The waters of the earth move continuously from the oceans, lakes, and rivers to the air, the land and back again to the waters. The sun's heat evaporates water, which condenses, then falls back to the earth as rain, snow or some other form of moisture. The scientific name for this moisture is *precipitation*. Most precipitation drops back directly into the oceans. The remainder falls on the land. In time, this also returns to the sea and the cycle starts again. This unending cycling of the earth's waters is called the water cycle.

Bio-Note

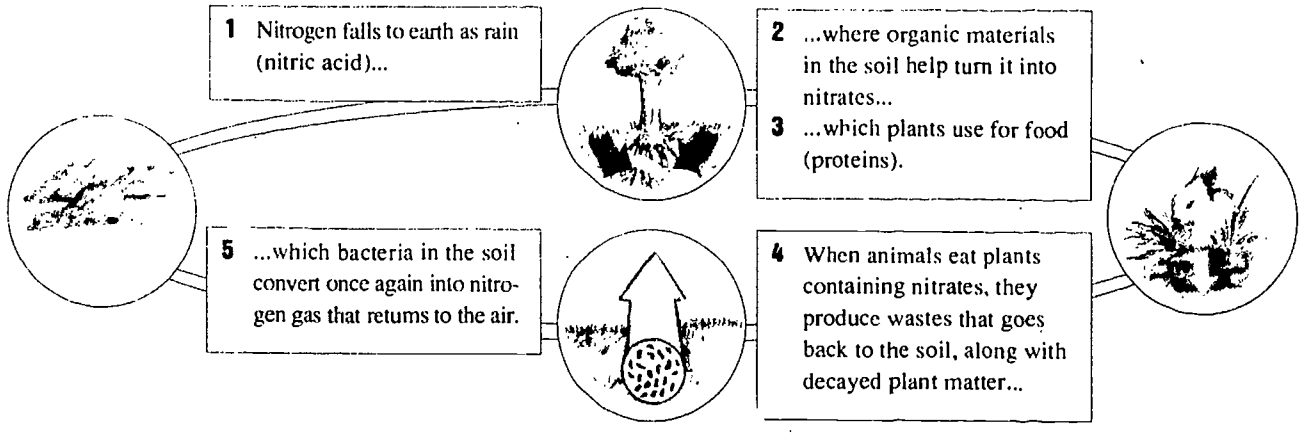
Water has the special ability to make things dissolve. Over time, water can dissolve minerals in the soil for plants to use, as well as gases, such as oxygen, for fish to breathe.



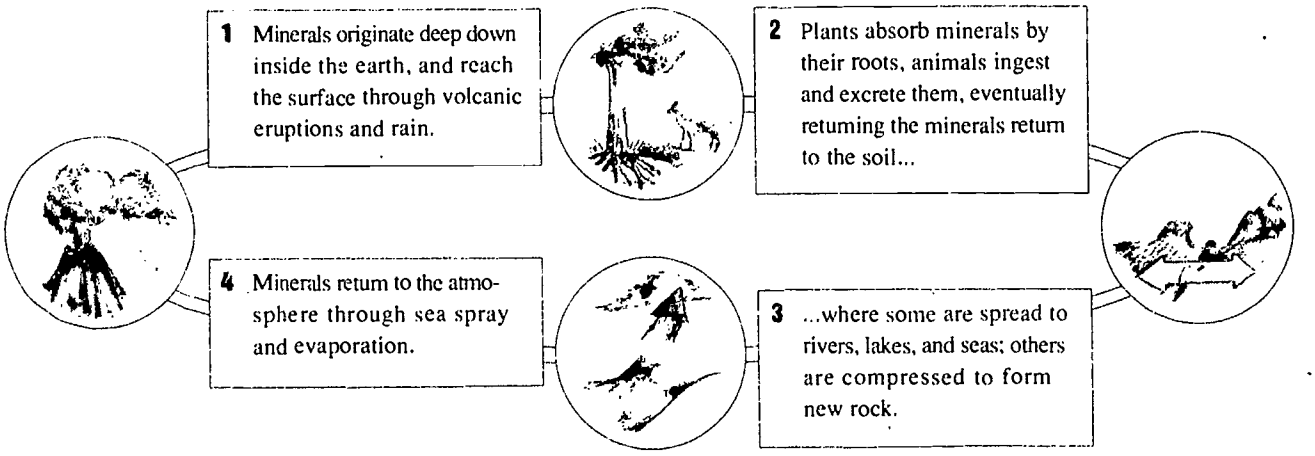
Carbon Cycle — Carbon is one of the basic elements of matter. It makes up less than one percent of all matter, but it forms part of all foodstuffs and every living thing. In this cycle, carbon is constantly circulating in many different forms through living things, the soil and the atmosphere. For example, plants absorb carbon dioxide from the atmosphere and water for photosynthesis. In turn the plants are eaten, digested and returned to the environment in the form of by-products containing carbon and gases. This matter is then decayed by decomposers, causing carbon to be returned to the soil and carbon dioxide to the atmosphere.



Nitrogen Cycle — All living things need nitrogen to build proteins for growth. Nitrogen, like other elements used by plants and animals, passes through a cycle of chemical changes and eventually returns to its original form. Obtaining nitrogen is a complex process. Although about 78 percent of air is made of gaseous nitrogen, it cannot be used by plants and animals in that form. For example, plants absorb nitrogen from the soil in the form of nitrates. When an animal eats the plant, it excretes nitrogenous wastes. Decomposers act upon these wastes along with the dead bodies of plants and animals. This decay produces a nitrogen product known as ammonia. Other bacteria use the ammonia and in doing so release nitrites as by-products. In turn, the nitrites are used by another group of bacteria to form nitrates, which can again be used by green plants.



Mineral Cycle — Minerals originate from the earth's surface or from deeper down through volcanic activity. Many contain elements like phosphorus and iron, which are needed for the life processes of plants and animals. For example, minerals blasted into the air by volcanic action settle on the land and are absorbed into the soil. These minerals are used by plants and animals and returned to the soil as by-products when death occurs. Minerals are also washed from the land into the seas. These minerals either settle out on the sea floor or remain dissolved in the water.



Discussion

Use the first activity, Apple Earth, to familiarize the group with their planet as well as create an awareness of issues such as waste management and composting. Following this activity, introduce them to the earth's four major cycles: water, carbon, nitrogen and mineral. Photocopy and distribute the *Earth Cycle Bio Sheet* (Appendix I). These will help the group understand the natural relationships within each cycle. The following activities help further illustrate the dynamics of each natural cycle.

Activity

Apple Earth

Distribute an apple to each group member along with a knife for slicing. Explain that you will use the apple to help put the various regions of the planet in perspective.

1. Have the group cut their apples length-wise in four equal parts. Explain that three of these parts represent the part of the earth that is covered by water.
2. With the remaining quarter have the group cut it in half width-wise. Explain that one half represents the area of the earth that is desert, arctic and swamps.
3. Have the group cut the remaining portion into four equal parts. Explain that three of the parts represent the area of the earth that has mountains, forests and land out of production due to inhabitation and non-agricultural usage.
4. Explain that the fourth portion ($^{1}/_{32}$ of original apple) represents the land suitable for cultivation.
5. Next, have the group peel the skin off this section. Explain that the skin represents the layer of topsoil usable for producing crops.
6. Eat the apple after discussing the Processing section and answering the Guiding Questions.

Processing

Hold up the pieces of the apple that represent the earth's cultivated land and land used by people. Help the group assess the impact people have had on the rest of the planet versus the impact of the planet on itself. To do this, help the group list the environmental changes caused by people. Likewise, see if they can list the impact nature has on itself, such as volcanic explosions, drought, flooding, hurricanes and fire.

Guiding Questions

- ❑ Do nature's cycles appear to be evenly balanced or in constant flux?
- ❑ How does nature react when the depletion of a resource occurs within an environment, such as when the balance of carbon dioxide and oxygen is off in a small pond?
- ❑ Can people influence nature's cycles?
- ❑ Where in earth's cycles are there opportunities for an excess of both manufactured and natural by-products to occur?
- ❑ Where in earth's cycles is there the opportunity for both manufactured and natural depletion of resources to occur?

Use the following activities to address these questions.

Materials

- ❑ apples
- ❑ knives

Bio-Note

Antarctica represents 1/10th of the earth's surface. The thickness of ice that covers this portion of land could cover the United States with a layer of ice two miles thick. This ice mass also contains more *fresh* water than all the rest of the world.

(World Book Encyclopedia, 1992)

Activity

Salty Seas

Explain that the ocean is salty because mineral salts from rocks have dissolved in the ocean. This happened gradually, over millions of years. First the rocks were broken and ground into soil by the action of ice, wind and rain. Eventually, rivers carried the soil to the ocean. The salts didn't evaporate as the water did; they stayed in the ocean.

1. To taste water as salty as the ocean, have each group member half fill a 12-ounce clear plastic cup with warm tap water.
2. Add one teaspoon of table salt to each cup and stir.
3. Have the group members taste the salty water.

Processing

Remind them that real sea water is similar yet different. It contains additional types of salt besides table salt, along with nutrients and elements like iron and gold.

Guiding Questions

- ❑ Where does the example of salt water fit into the mineral cycle?
- ❑ Could salt water be considered a form of natural pollution?
- ❑ Could industrial pollutants have the same effect?
- ❑ Does the salt remain in the water forever or does it evaporate with the water?
- ❑ Do other minerals exist in water? For example, why does some well water taste like iron?

Digging Deeper

You may wish to show a saucer that had salt water in it, which then evaporated. See if the group members can identify the white material left behind.

Materials

- ❑ 12-ounce clear plastic cups
- ❑ tap water
- ❑ salt
- ❑ measuring spoon
- ❑ stir stick

Activity

Effects of Nitrogen on Plants

Use this activity to show the dramatic effect of nitrogen on plants. Explain that nitrogen is critical for plant growth. It provides for the rapid growth of roots and stems and is responsible for the plant's color.

1. About four weeks before the group meets, start grass from seed in two separate pots.
2. Feed one pot with a liquid nitrogen fertilizer along with regular watering. Follow label directions so you don't burn the grass. Feed the other with water only.
3. By the time the group meets, the one treated with nitrogen should be more fully developed and green.

Processing

Ask group members to point out the differences between the two pots of grass. Be sure to pull up some of the roots for examination as well.

Guiding Questions

- ❑ How do the plots differ?
- ❑ Could a plant survive without nitrogen?
- ❑ Would more nitrogen give better results?
- ❑ Where does a plant's use of nitrogen fit into the nitrogen cycle?
- ❑ How could the nitrogen applied to crops help or hinder the nitrogen cycle?

Materials

- ❑ grass seeds (plant about one month before activity)
- ❑ two clay or plastic pots
- ❑ liquid plant fertilizer

Activity

Humans Exhale Carbon Dioxide

Use this activity to illustrate the role of air-breathing creatures on the carbon cycle.

1. Cut a head of purple cabbage into small pieces.
2. Place the pieces in a two-quart bowl.
3. Add enough boiling water to cover the cabbage.
4. Allow the cabbage to stand until the water turns blue.
5. Distribute cups to students and place 1 tablespoon of the solution in each cup and add 1/3 cup of water to each cup.
6. Instruct the group to blow lightly into the cups of cabbage water, using a straw.

Note: It may take time for a color change to take place, possibly five to seven minutes of vigorous blowing. Compare cups to detect variations in color.

Explanation

The cabbage water should turn from blue to a reddish color. This is caused when carbon dioxide from one's breath combines with the cabbage water to form a weak carbonic acid. The cabbage dye turns reddish when mixed with any acid. Demonstrate this by adding vinegar to a cup of the cabbage solution.

Processing

Help the group understand where air-breathing creatures fit into the carbon cycle. Ask if they can guess where most of the oxygen we breathe comes from. (Hint: 75 percent of the earth's surface is covered by this substance.) Use the following questions to further discovery.

Guiding Questions

- ❑ In what ways do we contribute to the carbon cycle?
- ❑ In what way do automobiles affect this cycle? How about motorcycles and motor boats?

Materials

Prepare 24 hours ahead.

- ❑ distilled water
- ❑ purple cabbage
- ❑ two-quart bowl
- ❑ 16-ounce clear plastic cups
- ❑ straws
- ❑ white vinegar

Activity

Make Your Own Water Cycle

This activity will help group members understand how water moves from the land, to the air, and back again.

Pour a little water into the bowl and place a small dry container into the center of the bowl. Cover with plastic wrap and tightly seal with a rubber band. Place weight on top of the plastic, then place bowl in the sun. The heat evaporates the water, which rises and condenses (like a cloud) on the cool plastic and falls into the container.

Materials

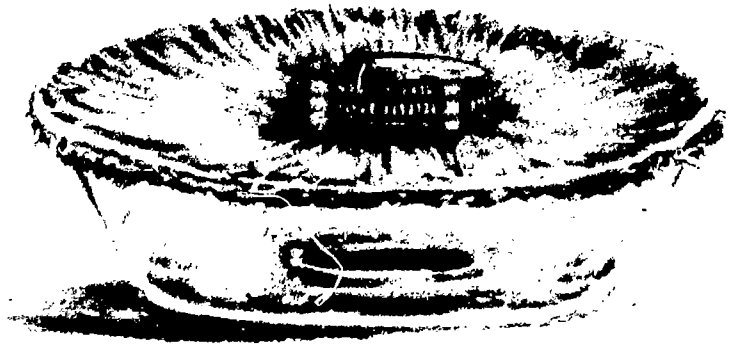
- ❑ large plastic bowl
- ❑ small container
- ❑ plastic wrap
- ❑ weight (3 quarters, taped together)
- ❑ rubber band

Processing

Help the group see how the water cycle connects the other cycles together. For example, water plays an important part in the movement of minerals in the mineral cycle. Likewise, water contains carbon dioxide that is used by aquatic plants in the photosynthesis process. It also moves nitrates through the soil to the roots of the plant.

Guiding Questions

- ❑ Where is water stored in the cycle?
- ❑ Where is water stored the longest in the cycle?
- ❑ Where does water move the quickest in the cycle?
- ❑ Where do manufactured and natural contaminants enter the cycle?
- ❑ Where is the greatest opportunity for the water to cleanse itself?



Going Beyond

Thinking Through the Cycles

Divide the group into four teams. Have each team prepare a visual presentation on one of the four natural cycles. The presentation can be dramatic, where each person represents a component of the cycle, or as simple as a walk through a garden showing how things interact within their cycle. Allow each team 15 to 20 minutes to prepare.

After each team has presented its cycle, have the entire group answer these questions:

Where does the energy come from in each of the cycles? For example, the sun provides evaporation in the water cycle, and photosynthesis in the carbon cycle.

Are the resources in each cycle infinite or finite?

Where are people in each of the cycles? For example, humans use water, air and minerals.

Going Beyond

Living Water Cycle

1. Have the group sit in a circle, each person holding a 12-ounce cup half filled with water. Standing in the center of the circle, explain that they represent the many places water is stored on the earth: in the ground, seas, lakes, rivers, atmosphere, ice caps, living beings.
2. Explain further that the water they hold represents the finite nature of the liquid in the environment. This means the amount never changes.
3. Show what happens when people or nature pollute the water. Put a few drops of blue food coloring in one of the cups along with three teaspoons of sugar. Stir well, then pour half of the mixture into the next person's cup. Stir again and pour into the next person's cup and so on until each cup has been contaminated. Compare the mixture in the first cup with that of the last. If the mixture looks clear, taste it to see if the sugar can be detected.
4. Explain that polluted water takes a long time to pass through the cycle. Also, due to the volume of water in the cycle, it takes a great deal of pollution to contaminate the entire system. Yet, consider water that has run off the land into the oceans for billions of years. Salt was picked up from the land and deposited into the oceans, making them salty.

Materials

- ❑ 12-ounce clear plastic cups
- ❑ water
- ❑ blue food coloring
- ❑ three teaspoons sugar

2 Life Within the Cycles

Existing in harmony with the natural cycles are three different types of life forms: producers, consumers and decomposers.

Producers — These are the plants that transform the sun's energy into chemical energy. This process is called *photosynthesis*. Using energy from the sun, plants combine water and carbon dioxide to make food. Some of the food is used by the plant right away for energy. Some is sent to the roots for storage. Some is used to create more of the plant itself. Food isn't the only product of photosynthesis. There's also a by-product called oxygen.

Consumers — These are generally referred to as living things that eat other living things. Some consumers eat producers. They're called *herbivores*, meaning plant eaters. When an herbivore eats a leaf, it's digesting food that was made in harmony with the sun and the earth's natural cycles. Some consumers eat other consumers. They're called *carnivores*, meaning meat eaters. Those consumers who eat both plants and animals are called *omnivores*.

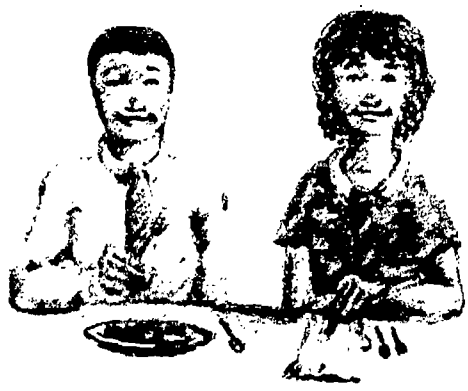
Decomposers — These are the vital "wrecking crews" of nature. Without them, the world would be littered with dead plants and animals. Decomposers eat the remains of dead plants and animals and some man-made products, releasing the elements that make up organisms back into their respective natural cycles. Decomposers, including bacteria, molds, fungi and earthworms, are nature's recyclers.

Other decomposers include fire, wind, rain, along with water and naturally-produced chemicals. These non-living decomposers play an important role in returning resources to their natural cycle. They also prepare the way for the living decomposers to do their job more effectively.

Objectives

The students will learn about:

- the differences between producers, consumers and decomposers
- the interaction among producers, consumers and decomposers
- the conditions necessary for decomposition to take place
- the relationship between mold, fungus and bacteria



Discussion

Review the interaction between producers, consumers, decomposers and the natural cycles. Explain how these living organisms are dependent upon each other and the cycles in which they exist.

You may wish to have a terrarium or aquarium available to illustrate the balance between the natural cycles and living organisms. To construct a terrarium, place a layer of small stones at the bottom of a fish tank. Then add two inches of topsoil. Dampen the soil and add a variety of plants to create a mini-forest. With a glass top and a warm, well-lit spot out of direct sunlight, the plants should flourish.

Continue your discussion by emphasizing the role and location of decomposers in nature's cycles, including plants, mammals, worms, and insects. (Refer to the *Earth Cycle Bio Sheet*, Appendix I.) Explain that decomposers convert the remains of consumers and some manufactured products into reusable elements. Decomposition initiates two very important cycles: carbon and nitrogen. These building blocks of life are sometimes limited and non-renewable. At the point of decomposition, the remains are reduced to ammonia, nitrites, and, finally, nitrates and free nitrogen. Nitrates fertilize the soil while bacteria change nitrogen into usable forms for life. Use the following activities to demonstrate the nature and effects of decomposition. To stimulate the discussion, locate a natural item, such as wood, in various stages of natural decomposition.

Materials

- ❑ 10-gallon fish tank (or gallon plastic jug)
- ❑ glass or plastic top
- ❑ gravel
- ❑ charcoal
- ❑ topsoil
- ❑ a variety of plants

Activity

Observing the Presence of Molds

Use this activity to illustrate the existence of molds in the environment. Be sure to stress the fact that the mold they see was not put there by you. Rather, it existed undetected until the right conditions occurred.

1. About five days before this session, place a slice of white bread in a plastic bag. Put 10 drops of water inside the bag and seal. Keep the bag in a dark, warm place.
2. During the meeting, observe the bread for any changes. A black, hairy-looking structure will be seen growing on the bread.

A piece of blue cheese may also be used for this activity. The presence of the mold on the moist cheese combined with the pungent aroma will remind the group of the moist conditions needed for decomposition to occur along with the smell of decomposers at work.

Processing

Mold is a form of *fungus*, a Latin word meaning "food robbing." It can grow and reproduce very quickly. Mold produces very tiny cells with hard coverings called *spores*. Spores are smaller than dust particles and float through the air. The spores were already on the slice of bread when it was placed in the plastic bag. The water, warmth and darkness provided a good environment for the mold to grow. Stress the fact that molds (decomposers) help return nutrients to their natural cycles.

Materials

Prepare materials about five days ahead.

- ❑ one slice of white bread
- ❑ plastic bag

Activity

Bacterial Growth and Temperature

Use this activity to demonstrate that bacteria (decomposers) are everywhere and that temperature influences their growth.

About seven days before this session put a cup of fresh milk in two separate containers. Place one in the refrigerator and the other in a warm place. Eventually, the milk left unrefrigerated will become thick with white lumps. The cold milk, on the other hand, should remain drinkable.

Processing

Explain that warm temperatures promote the growth of bacteria that can decompose food. Cooler temperatures slow down bacterial growth, but even refrigerated milk will eventually spoil if left long enough.

Guiding Questions

- ❑ Why is it important that bacteria are seemingly everywhere?
- ❑ Why do warmer temperatures increase the growth of bacteria?
- ❑ Do you think extremely warm temperatures could slow the growth of bacteria, as in a desert environment?

Materials

Prepare materials about one week ahead.

- ❑ one cup fresh milk
- ❑ one container

Activity

Effects of Yeast on Food Decomposition

Use this activity to introduce the fact that fungi, like yeast used in making bread, are also natural decomposers.

About seven days before this session cut two slices from a banana. Place each slice into separate plastic bags. Sprinkle one-half teaspoon of yeast on one banana slice then seal the bags. Be sure to mark the bag with the yeast. Place both bags in a warm, dark place. After seven days, the slice with the yeast should show the faster decomposition.

Processing

Explain that yeast is one of 100,000 different kinds of organisms that make up the fungi group. Since they lack the ability to change sunlight to food, they depend on other organisms for food. The yeast feeds on the banana, causing it to break into smaller parts. This breakdown is referred to as decay. Decomposers are an important part of the world because there is much dead material that must be broken into smaller parts.

Guiding Questions

(for all three activities)

- ❑ How are fungi and molds different from bacteria? How similar?
- ❑ Do fungi, bacteria and molds decompose materials under the same conditions?
- ❑ Under certain conditions, are fungi and molds better suited for decomposition than bacteria?

Materials

Prepare materials about one week ahead.

- ❑ two slices banana
- ❑ plastic bags
- ❑ one-half teaspoon yeast

Activity

Factors Necessary for Decomposition

This is a good activity to further the group's understanding of the conditions necessary for decomposition.

1. Two weeks before this session, fill four clay pots with good topsoil. Place pot 1 in an oven and heat it to 400°F for one-half hour. Be sure pot has cool before handling.
2. Cut four one-inch cubes of raw potato. Bury a cube in each pot two inches below the surface of the soil.
3. Place pots 1 and 2 side by side in a location away from a window. Pot 2 should never be watered. Put pot 3 in the refrigerator and pot 4 in a sunny window. Do not disturb the experiment during this period, except to occasionally moisten the soil of pots 1, 3 and 4.
4. During the session, carefully remove the soil from each potato. Have the group examine what happened to each piece. Determine things such as which piece decayed the most, which types of decomposers were at work on the potato and what conditions are best for decomposition.

Processing

Have the group think about places where they've seen decomposition taking place. Note the scope of decomposition. For example, if they saw a tree decomposing in a forest, was the entire tree decomposing at the same rate, or were different parts decomposing at varying rates? Were those parts in contact with the soil decomposing more quickly?

Guiding Questions

- ❑ Why is decomposition such a slow process?
- ❑ Are there ways to speed up decomposition?
- ❑ How could one control or stop decomposition?
- ❑ Are there times when it's desirable to speed up decomposition?

Materials

Prepare materials about two weeks ahead.

- ❑ four clay pots
- ❑ one raw potato
- ❑ top soil

Impacting Decomposition

Use this activity to further your group's understanding of the role of decomposers in earth's natural cycles. It will also help them appreciate the relationship between producers, consumers and decomposers.

1. Separate the group into producers, consumers and decomposers. Explain the role of each in nature. Give each producer a lump of play clay and have them roll it into a ball. Once completed, have the consumers take the balls of clay from the producers and fashion them into cups. Then, instruct the consumers to throw away the cups to the decomposers so they may flatten them out (the act of decomposition in this activity) for eventual reuse by the producers.
2. Repeat the cycle, but this time have the consumers add bread crumbs to their cups, making it difficult for the cups to be flattened (decomposed). In the following cycle, have the consumers put their cups into sturdy containers for eventual flattening (decomposition).

Processing

After the group observes the difficulties created by the bread crumbs and the containers, have them consider similarities in the real world. Think about the unnatural things products are placed in or painted with, as well as where they are disposed, like compost piles and landfills. Remind the group where decomposers live and the conditions they require to work best.

Guiding Questions

- ❑ Consider ways products are altered so decomposition is slowed—for example, the pasteurization of milk (heated to 180°F for three minutes) or the addition of preservatives. How is this like the bread crumbs that were added to the play clay?
- ❑ Consider ways products are stored so decomposition is slowed—for example, the disposal of by-products in a landfill, or placing food in a refrigerator. How is this like placing the play clay in a sealed container?

Cooked Play Clay

Prepare 24 hours ahead, one batch per group of eight students.

1 cup flour
1/2 cup salt
2 tsp. cream of tartar
1 cup water
1 tbsp. vegetable oil

- Cook in pot over moderate heat until ingredients form a ball.
- Knead with hands.
- Store in an air-tight container.

3 Plastics from the Carbon Cycle

The word plastics comes from the Greek word *plastikos*, which means "able to be molded." Manufacturers make plastics from fossil fuels by turning them into synthetic resins. Fossil fuels are the remains of prehistoric plants and animals, the storehouse of the earth's carbon for the carbon cycle.

The process of making these synthetic resins from fossil fuels is called *polymerization*, similar to making cheese from milk. In this process, molecules called *monomers* combine with each other to form larger molecules called *polymers*. It's these unique man-made polymer chains that give plastics their special characteristics.

Scientists and engineers have developed hundreds of plastics that can be described as either hard or soft, transparent or opaque. Hard plastics are used to make such products as dinnerware, football helmets, clock cases, radios, cameras and flashlights. Soft plastics are used to make flexible products such as toys, squeeze bottles, dishpans, garbage cans and flower baskets. Transparent plastics may be either hard or soft. Some have color while others are clear. These clear plastics are widely used as envelopes to package foods, medicines and clothing.

Plastics are also given special properties such as resistance to heat, light or chemicals; the ability to be drawn into fine threads, then woven or knitted into fabric; and decorative textures which resemble leather, marble, ivory, gold and so forth.

Objectives

The students will learn about:

- the relationship between plastics and the carbon cycle
- the molecular makeup of plastics,
- the properties of plastics
- the proliferation of plastics in the environment

Bio-Note

Remember — starch and cellulose are polymers of sucrose (table sugar).

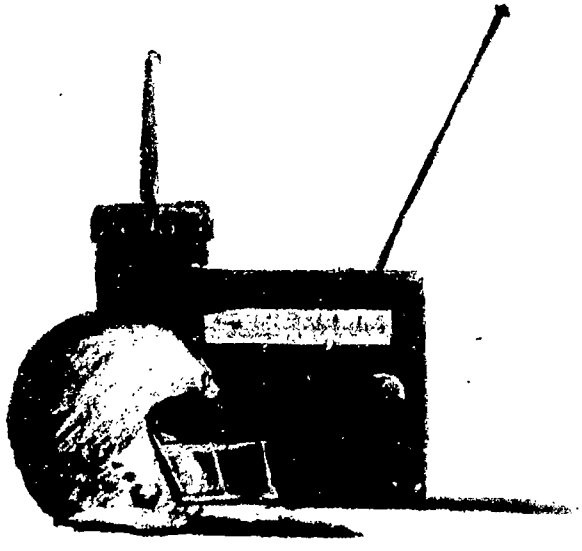
Bio-Note

The first plastic was developed more than 100 years ago as an alternative to ivory for pool balls and piano keys.

Discussion

Ask if anyone knows what a polymer is. Have someone look up the word polymer in a dictionary. *Poly* comes from the Greek word for "many," and *mer* from the Greek word for "part." Together, they mean "many parts."

Explain further that petroleum-based polymers, otherwise known as plastics, are made from fossil fuels that come from the carbon cycle. Refer to the *Earth Cycle Bio Sheet* (Appendix I). Show the group where the fossil fuels are stored within the carbon cycle and where humans are as consumers.



Activity

Make a Super Chain

Help the group understand the nature of plastics. Explain that the group is going to create its own polymer chain from a make-believe resin. Distribute scissors and construction paper to each group member.

1. Have each of them fold the sheet of construction paper lengthwise. Then, tell each student to cut the construction paper like the diagram. Note that all the cuts are to be about one-quarter inch apart and end at least one-quarter inch from the edge. Also note that the cuts alternate from the folded edge to the open edge.
2. Once the cuts have been made, make a final cut along the folded edge as shown. Carefully open the folded piece of paper to form a large link or "monomer."
3. Next, tape the links together to form a massive group chain or "polymer."

Materials

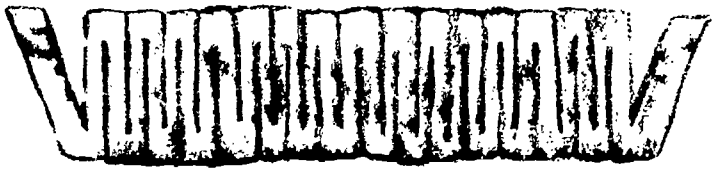
- ❑ scissors
- ❑ construction paper
- ❑ tape
- ❑ rulers

Processing

Explain that each loop in the chain is called a monomer; loops link together to form a polymer. As a group, demonstrate the versatility of the chain by twisting and stretching it. Point out that the chain, like certain plastics, can be molded or twisted yet retain its basic structure.

Have the group speculate how its chain is like a piece of plastic, as suggested in the discussion section. You may wish to have some examples of plastics on hand to aid the discussion.

You can also create a polymer using colored paper clips in repeating patterns to illustrate various chemical arrangements.



1 and **2**

3

Making Polymers

Use the following demonstrations to familiarize group members with early plastics as well as their distinctive properties.

These first plastics were made from natural sources such as milk, trees and plants. Use the following experiments to demonstrate the properties and makeup of these first plastics. If you use group members for parts of these demonstrations, be sure to take proper safety precautions.

Molding With Milk

Materials

- ❑ one cup milk
- ❑ three tablespoons white vinegar

Warm milk in a pan. Stir in vinegar. A white rubbery material forms. Take this out, wash it under the tap and shape it into objects such as marbles. Leave it for a few days, and the material will harden.

Demonstration

Explain to the group how the vinegar and milk react to coagulate *casein*. Protein molecules in the milk, which are so long they can bend, join to make the casein rubbery. As the material dries, the casein molecules shrink, making it hard.

CAUTION

Acetone can irritate the skin on contact. Use protective gloves and perform the experiment with proper ventilation.

Plastic From Trees

Materials

- ❑ cellulose (sawdust)
- ❑ three ounces acetone
- ❑ three ounces 95 percent denatured alcohol
- ❑ two teaspoons castor oil
- ❑ glass or wood stirring rod
- ❑ glass jar with metal lid

A popular craft material, similar to several commercial products, can be prepared by mixing 20 grams of cellulose (sawdust) in a preparation of three ounces of acetone, three ounces of 95 percent denatured alcohol, and two teaspoons of castor oil. Stir until the cellulose is completely mixed with the other ingredients. Use a glass or wood stirring rod. To prevent evaporation, keep the mixture in a glass jar with a metal lid. Do not use a plastic container or cover. The wood dough should be moist enough to hold together without cracking when used.

Digging Deeper

Go on a Plastic Hunt

1. Have the group break into teams of two or three to search their immediate environment for plastics. You may wish to provide the students ahead of time with specific items made of plastic. Give the students at least 10 minutes.
2. When the group returns, have them write what they found on a large piece of paper. Post the list so it can be seen by others.
3. Once the groups have posted their findings, ask them to look for similarities between the lists. Help them understand the scope and diversity of plastics in their environment.

Materials

- ❑ flip chart or chalk board
- ❑ variety of plastic products

Digging Deeper

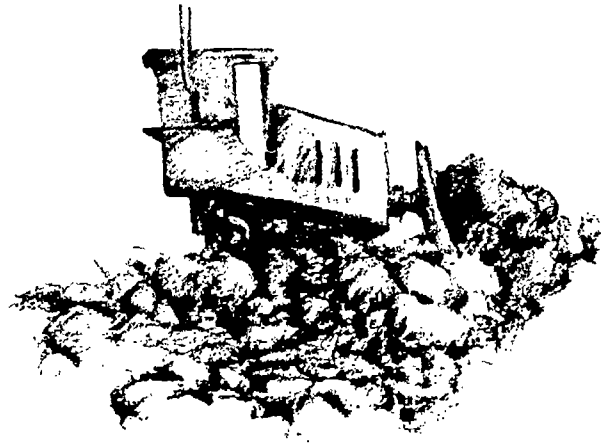
Plastics in the Environment

Have the group describe what comes to mind when they think of plastics. Make a list on a flip chart or chalk board. Have them consider why there are so many types of plastics. Stimulate discussion by having a variety of plastic products on hand such as cellophane tape, polyester fabric, ping pong ball, eyeglasses, ice cube tray, paint, garden hose, soft drink bottle, milk jug, yogurt container, non-stick appliance, pipe, drink cup, plastic wrap, coffee can lid, etc.

4 Disturbing the Cycles

Nature's cycles (water, carbon, mineral and nitrogen) help maintain a balance in the world in which there are no lingering by-products. Over time, everything is broken down and re-used. People, however, tend to cause an imbalance in this system with manufactured goods. Ever since humans first gathered in settlements there has been waste. In more recent times, many things produced by people decompose slowly and do not return to nature's cycles in a timely fashion. People also disturb these cycles by generating excess by-products beyond the capacity of the cycles to re-absorb them. In the United States, people generate mountains of garbage — 195.7 million tons each year. That's enough to fill a bumper-to-bumper convoy of garbage trucks halfway to the moon.

Certain plastics are not readily degradable. They tend to remain outside nature's cycles for long periods, reducing to some degree the amount of resources available. In addition, plastic takes up room in a landfill. Of the trash thrown away, only 8 percent by weight are plastics, mainly packaging of various kinds. However, that 8 percent takes up to 20 percent of the landfill space. This is because they are rigid and do not totally collapse. Most plastic garbage is packaging, including bottles, jars, lids, wrapping, plastic bags and plastic foam containers.



Objectives

The students will learn:

- about the existence of plastic waste
- disposal difficulties with plastics
- characteristics of a landfill
- problems with incinerated plastics

In response to this situation, some larger municipalities are beginning to rely upon incineration as a method of reducing the volume of solid waste entering a landfill. Although this method has proven useful, it's not without drawbacks. For example, burning mixed waste can produce toxic fumes that must be collected by an expensive scrubbing apparatus, as well as increase the amount of carbon dioxide released. Likewise, incinerated waste can create a toxic ash that can leach into water supplies when placed in a landfill.

All Waste in U.S. — 1990*

From Business and Households
(Does not include construction debris and agriculture)

Material	Total (Mil.Tons)	Percent Recycled or Composted	Percent Incinerated or Landfilled
Paper and Paperboard	73.3	28.6%	71.4%
Yard wastes	35.0	12.0	88.0
All plastics	16.2	2.2	97.8
Metals	16.2	23.0	77.0
Glass	13.2	19.9	80.1
Food wastes	13.2	0.0	100.0
Wood	12.8	3.2	96.8
Textiles	5.6	4.3	95.7
Rubber and Leather	4.6	4.3	95.6
Other	6.1	13.1	86.9
Total	**195.7**	**17.1**	**82.9**

**The Green Consumer Letter*, November 1992, excerpted from *Characterization of Municipal Solid Waste in the United States: 1992 Update*, publication PB92-207166, available for $19.50 ppd. from the National Technical Information Service: (703) 487-4650.

Bio-Note

The Purpose of a Package:

- ❑ preserve the product
- ❑ protect the product
- ❑ hold the product
- ❑ protect the health of the consumer
- ❑ provide advertising
- ❑ promote purchasing
- ❑ provide convenience
- ❑ make the product look good
- ❑ increase shelf life
- ❑ reduce weight
- ❑ inform the consumer
- ❑ allow for transportation
- ❑ add your own _____

Discussion

Talk about the convenience of plastic packaging. Illustrate how many product packages have gone from glass or metal to plastic within the last few years. See Bio-Note on *Purpose of a Package* to help the group understand why packaging is necessary. Follow with the first activity to further sensitize them to the use of plastic packaging. From this point, use the second activity to help them understand the volume of used plastics that are generated by consumers. Stress that a finite resource like fossil fuel is being taken out of the carbon cycle to make them.

Activity

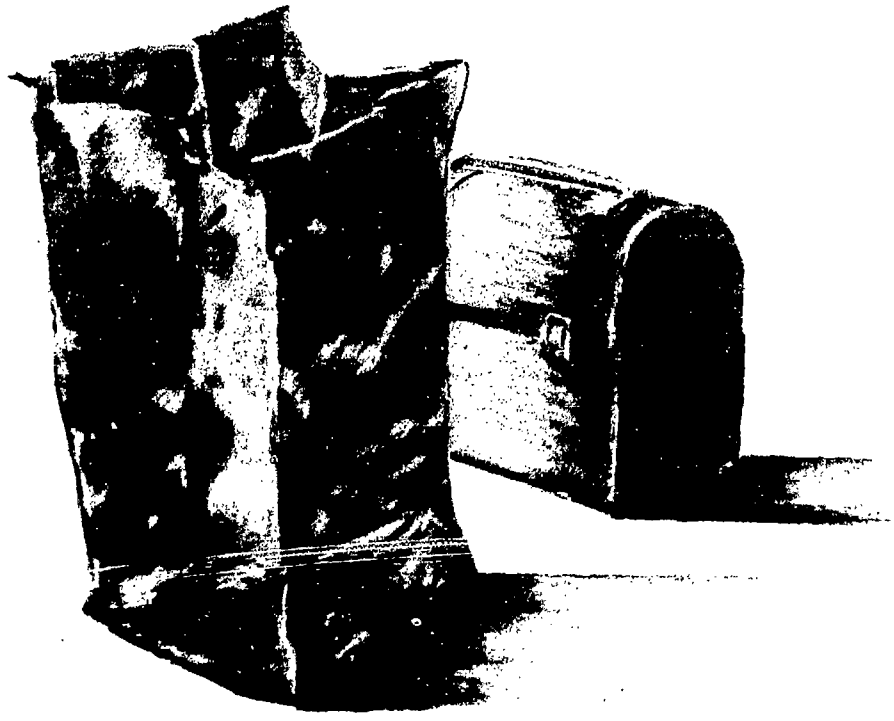
Pack a Snack

Use this activity to sensitize your group to the variety of ways in which packaging is used.

1. Before this meeting, ask the students to pack a snack or a lunch. When they arrive, have them eat what they brought. After they are finished, have them place their leftovers in a pile.
2. Have the group inventory all the plastic items that accompanied what they ate: plastic bags, paper bags, cans, bottles, drink boxes, wrappers, etc. Were these items brought out of necessity, habit or convenience? Which items are reusable?
3. Use this activity as a way of reminding the group where they left off last time.

Materials

- ❑ sack lunch or snack (ask the group to bring one ahead of time)



Digging Deeper

Left Behind

Help your group understand the volume of waste that is generated by consumers. On the basis of the experience gained from the first activity, see if the group can determine which types of plastics are most commonly found in the trash can, along the highway or in grocery stores.

Going Beyond

Disposal Difficulties with Plastics

Refer to the *Earth Cycle Bio Sheet* (Appendix I) for this part of the discussion. Explain that once the fossil fuels are used to make plastics, it is difficult to put them back for two reasons:

1. there are few naturally-occurring decomposers of fossil-fuel derived plastics in the environment;
2. the conditions in which many existing petrochemically-derived plastics are currently disposed (in landfills) do not encourage decomposition.

Set the stage for further discussion by showing a mock landfill. This should consist of an aquarium or large clear container filled with soil, plastic packaging, paper, cans, food, grass, newspapers and other materials. Remind them that the example they see is not much different from a real landfill.

Consider setting this up in advance to illustrate how slowly things decompose, if at all, in landfill conditions. Remove the tank from all light and seal it from moisture. Ask the group to identify pieces of trash that have changed and pieces that have not.

Bio-Note

Municipal landfills are dry, dark and airless places; they are intended to be air-tight and watertight to avoid contaminating underground water. These conditions actually preserve garbage. Researchers have recovered 25-year-old newspapers from a landfill and found them still readable. Without water, even natural products, such as apples, break down very slowly.

Going Beyond

Look at Landfills

Continue the discussion of items that are discarded in a landfill. List the items on a flip chart or chalkboard. Help the group include all types of household waste that end up in landfills, especially plastic packaging.

Give group members a copy of the map, *Landfills Get Full* (Appendix II). Read the title at the top and look at the map together. When you are sure that the group knows how to interpret the shaded areas on the map, ask them to answer the questions below the map.

Processing

When group members have completed their work, go over their answers together. Take time to explore some of the issues that arise during the discussion.

Materials

Consider conducting this activity at an actual landfill site.

- ❑ chalkboard or flip chart

Going Beyond

Consider the Alternative — Incineration

Have the group identify the pros and cons of incineration. Does it reduce the volume of trash going into the landfill? What is its long-term impact on the environment? Does incinerated material take up much or little space? Does it generate potentially toxic fumes and ash? Does incineration cost more to operate than a landfill? Does it accelerate the greenhouse effect by production of carbon dioxide?

5 Natural-Tech Solutions

An alternative to managing the solid waste created by plastic packaging is to have it behave like natural materials. Scientists have developed ways of making plastics from natural sources like corn, potatoes, cheese whey, soybeans and sugar beets. These new plastics are referred to here as **biodegradable polymers**.

Since biodegradable polymers are intended to be completely biodegradable, they can be mineralized in a matter of a few weeks or up to a couple of years into carbon dioxide, water and biomass, allowing them to recharge the natural cycles from which they came. In contrast, some plastics, like polyethylene, are not considered biodegradable because they may take hundreds of years to decompose.

The biodegradable polymer material will be targeted for certain product applications that will alleviate some of the stresses to the environment. (A plastic six-pack holder can entangle animals.) Unlike ordinary plastics, biodegradable polymers biodegrade in a compost facility. This creates humus for use at home or in the community. Humus is a soil amendment that is full of nutrients that benefit the soil, plants and carbon cycle.

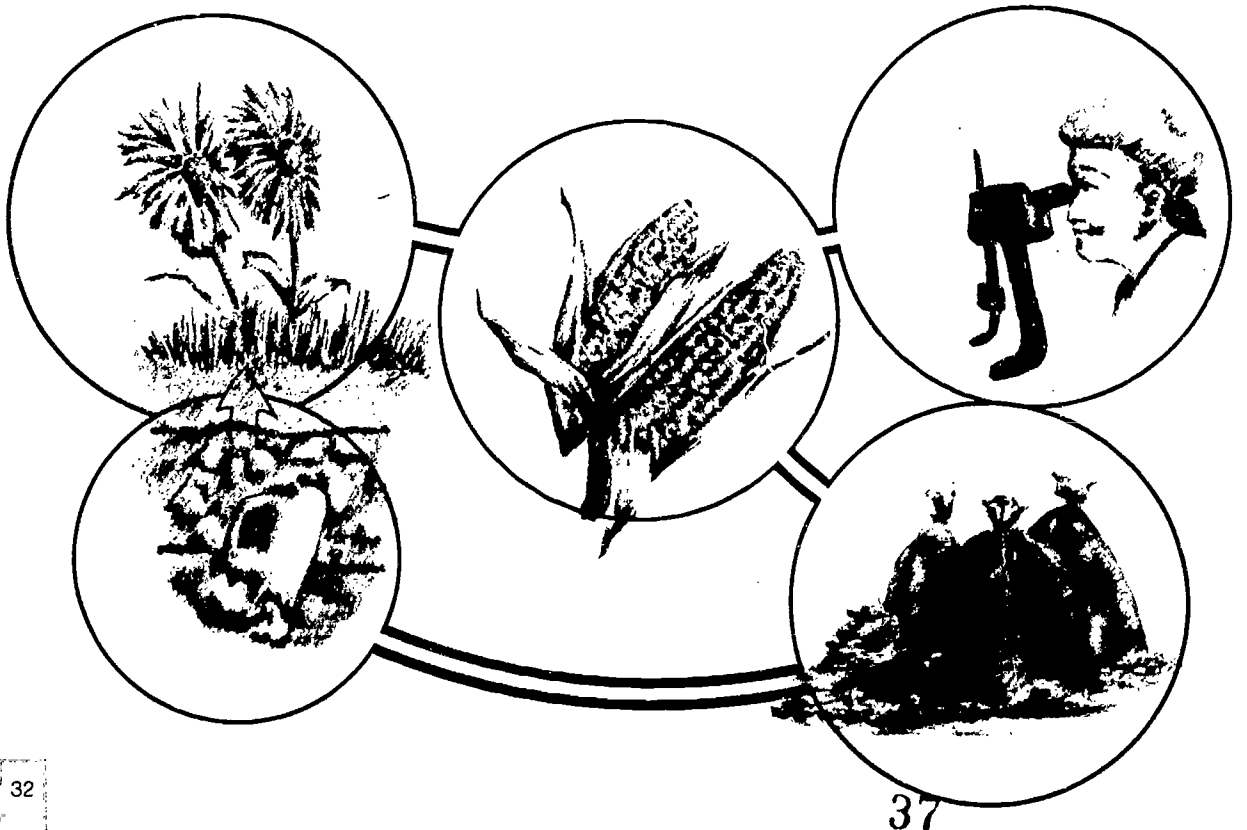
Objectives

The students will learn about:

- the existence of biodegradable polymers from renewable resources
- the use of starches, sugars and lactic acid in biodegradable polymers
- the characteristics of biodegradable polymers
- potential products from biodegradable polymers

Bio-Note

Just because biodegradable polymers break down relatively quickly does not give people the right to litter.



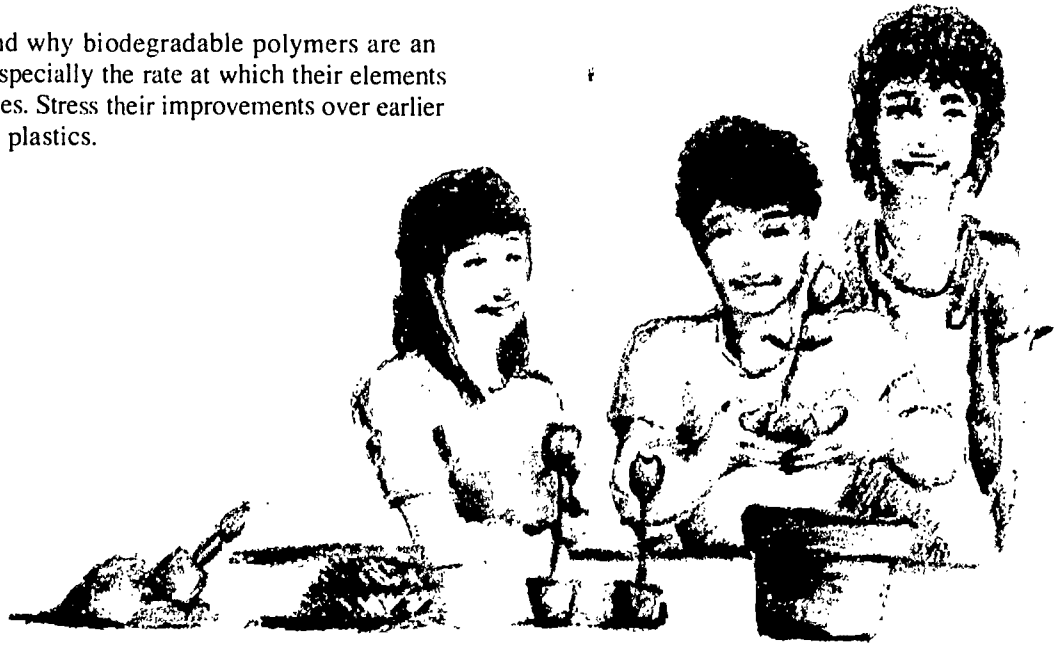
By applying humus in landscaping or agricultural applications, the organic content in the soil is increased, which in turn provides a more nutritive environment for plant growth. Humus also supports plant growth by increasing water retention in the soil and reducing desertification. The resulting plant growth helps to keep the carbon cycle in balance by taking carbon dioxide out of the air through photosynthesis. In this way, biodegradable polymers can fit into the carbon cycle through organic recycling.

This type of truly biodegradable product is not to be confused with products with similar degradable claims. For example, a few years ago, manufactures added cornstarch (8 to 10 percent) to polyethylene in the manufacturing of trash bags. However, once the microorganisms decomposed the cornstarch, the polyethylene portion of the product still remained.

Other types of degradable plastics include those described as *photodegradable*. This means they break apart in the presence of sunlight. However, traditional photodegradable plastics, such as those used as surface covering, or mulch, for melon, strawberry and pineapple crops, still leave a residue once the product breaks apart.

Discussion

Help the group understand why biodegradable polymers are an important breakthrough, especially the rate at which their elements are returned to natural cycles. Stress their improvements over earlier bio- and photodegradable plastics.



Activity

Understanding Biopolymers

One way of making biodegradable polymers is through the use of starch-based resins. Review the fact that starches used in some biodegradable polymers come from renewable resources such as corn, potatoes and rice. To demonstrate the existence of starches in foods, prepare one of the following examples before this lesson.

(If you don't have access to a microscope, pour starches through a cheesecloth and wait 24 hours. This will yield an amount of starch that the group can easily see and feel—and it will form a powder for the next Activity.)

Corn

Thaw a package of corn and place in a bowl. Crunch up the corn with a potato masher and cover with water. Let stand for about 15 minutes. Remove the corn from the bowl. Allow the water to stand for about 15 minutes. Gently pour the water through a piece of cheese cloth, allowing the starch to become trapped in the cloth.

Potato

Slice a potato into a bowl. Cover it with cold water and let stand for 20 minutes. Remove the potato and let the water sit for 15 minutes. Gently pour the water through a piece of cheese cloth, allowing the starch to become trapped in the cloth.

Rice

Place rice in a bowl of water and let stand for about 30 minutes. Remove the rice from the bowl. Allow water to stand for about 15 minutes. Gently pour the water through a piece of cheese cloth, allowing the starch to become trapped in the cloth.

Processing

Explain that starch naturally exists in corn, potatoes and rice. Test for the presence of starch left behind in the cheese cloth. Place a few drops of iodine onto the areas of the cheese cloth where the liquid passed through. If starch is present, the iodine changes from a reddish-brown to a blue-black.

Have the group examine the starch water under a microscope. When starch particles are placed in water, they swell in size, making them easy to see. Place one drop of iodine in the solution after placing onto a glass slide to help them stand out.

CAUTION

This activity should not be performed without adult supervision. Iodine is toxic. Wear protective gloves.

Materials

- ❑ one potato
- ❑ one package frozen corn
- ❑ uncooked rice
- ❑ bowl
- ❑ water
- ❑ cheese cloth
- ❑ iodine solution
- ❑ microscope or hand lens

Bio-Note

Biodegradable polymers can reduce our dependency on foreign oil and provide more markets for American farmers because they utilize agricultural resources produced in the United States.

Activity

Characteristics of Starch-based Biodegradable Polymers

1. Show what cornstarch is like. Allow them to taste and feel the powder.
2. Provide the cups, water, cornstarch and stir sticks. In the cup, have them mix three tablespoons of the corn starch with one and one-half to two teaspoons of water. Stir the mixture until it forms into a workable paste.
3. After a few minutes, the cornstarch will be somewhat workable like a putty. If the putty is placed in a microwave oven on high for 15 seconds, it will provide a more consistent product for examination.
4. Use the polymer wrapping from this workbook as an example of a polymer-based product. Compare it with the cooked corn-starch material they just made.

Processing

Have group members compare the product they made with the polymer materials on hand. Review the following questions.

Guiding Questions

- ❑ What benefits are there to products that are made from materials like starches, and other agricultural-based products, such as lactic acid?
- ❑ How will the use of such materials impact the earth's natural cycles?
- ❑ What are the best ways to dispose of such products?
- ❑ What are the costs to make these products?

Materials

- ❑ three tablespoons of cornstarch
- ❑ 12-ounce clear plastic cups
- ❑ one and one-half to two teaspoon water
- ❑ stir sticks
- ❑ microwave oven (optional)
- ❑ other polymer-based products (see below)

When this Workbook Wrapper is Gone...

To obtain additional biodegradable polymer materials, such as packaging peanuts, contact local moving companies and private postal franchises.

Sample Analysis

Have the group consider the difficulties in changing cornstarch, like the putty they made, into a usable and totally degradable product. Next, have them make a list of the products' characteristics such as weight, strength, biodegradability and texture.

See if they can guess the challenges in producing totally biodegradable polymers. For example:

The packaging needs to be durable yet degradable in biologically-active environments.

The packaging provides a container that degrades only when intentionally exposed to moisture and other elements.

6 Cycling Back

Composting and Water Solubility

Given what is known about the disposal of solid waste through recycling and reducing, landfills and incinerators, attention should be given to additional measures like composting and waste water treatment. Since many of today's biodegradable polymers are intended to be completely biodegradable, composting and waste water treatment are the correct disposal methods for these products. Home and municipal composting are also excellent ways to divert organic waste from landfills and incinerators.

Potentially compostable materials, which make up approximately 40 percent of the waste stream, include leaf and yard trimmings, food scraps, food-soiled papers and other non-recyclable but compostable papers. All these can be returned to the natural cycles through composting.

Objectives

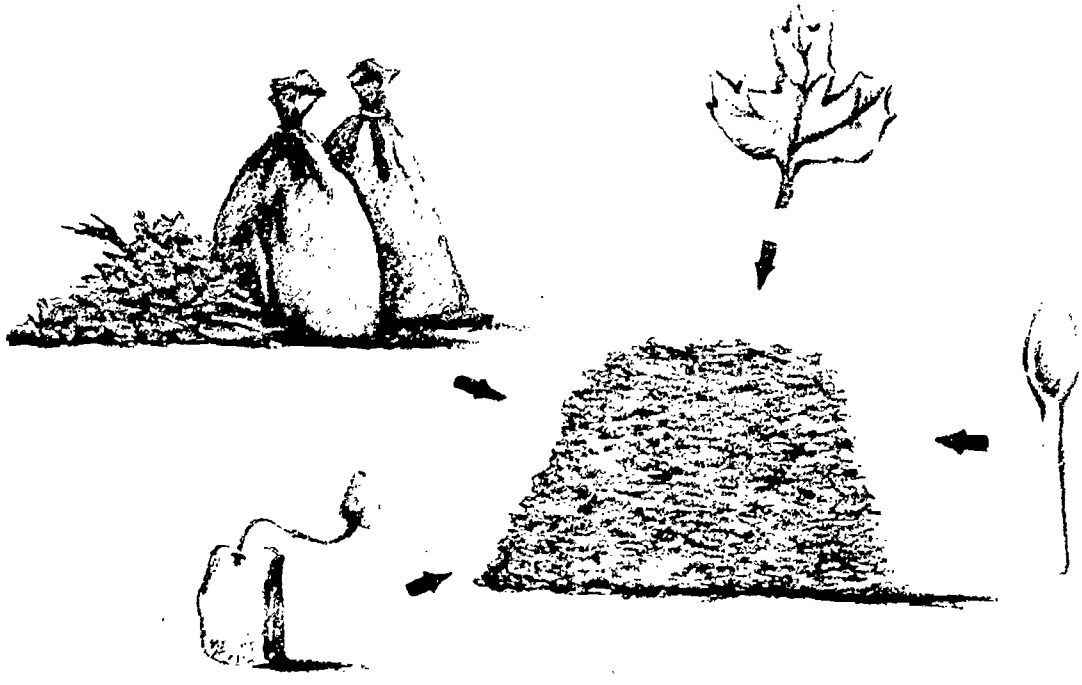
The students will learn about:

- proper disposal of biodegradable polymers
- seven natural cycle advantages
- how composting works
- the influence of climate on decomposition
- the water treatment process

Bio-Note

In 1992, there were nearly 3,000 municipal composting facilities in the United States. If leaf and yard composting continues, this number will continue to grow.

(Bio-Cycle Magazine)



Discussion

Help the group see that composting is nature's way of recycling — returning carbon to the natural cycle to be used again. In many parts of the country (especially agricultural areas) composting is less expensive than landfilling or incineration, does not require a lot of fuel or energy and it can produce a high quality product that can be put back into the soil.

Activity

How Composting Works

Using the handout, *Composting: Wastes to Resources* (Appendix III), illustrate how a compost pile works. Explain that composting requires the separation of food scraps and other biodegradable materials from the waste stream so they can degrade naturally into a rich soil material called humus. In a well-maintained compost pile, biodegradable materials are piled layer upon layer providing the right balance of moisture and temperature for the decomposers to survive. (Be sure to stress this last point.)

Show them examples of naturally-occurring humus in the environment. Have them smell and feel the examples that you brought. Have several hand lenses available for closer examination.

Processing

Ask which group members have a compost pile at home. Encourage those who don't to start one. Explain that humus makes a wonderful soil amendment for all types of plants and shrubs.

Materials

- ❑ *Composting: Wastes to Resources* (Appendix III)
- ❑ examples of naturally-occuring humus
- ❑ hand lenses

Activity

Biological Decomposition Around the World

Stress the need for maintaining a balance between temperature and moisture for biological decomposition to take place. Have the group consider the effect of each of the world's four climatic regions (polar, temperate, desert and tropical) on decomposition. The following facts will aid the discussion.

Polar — a treeless plain of mostly level land; the subsoil is permanently frozen; only a few inches thaw during the short summers.

Desert — has less than 10 inches of rainfall annually; heat builds up quickly during the day but is quickly lost at night; roots of most desert plants spread out in all directions and are only a short distance below the ground.

Temperate — characterized by definite seasons and wet and dry periods; has an average yearly rainfall of more than 40 inches and a distinct yearly variation in length of days and nights.

Tropical — warm areas near the equator experience more than 70 inches of rainfall annually; there is no distinct dry season and little temperature variation; contains most variety of plants and vegetation.

Processing

Discuss the advantages and disadvantages of composting in each region along with the relevant need. Consider alternative waste disposal methods for areas that have a high population density.

Guiding Questions

- ❑ If temperature and moisture are factors of decomposition, is composting the best method of disposal in subzero conditions?
- ❑ Is there an advantage to having a product that is compostable, like a spoon made from a biodegradable polymer?
- ❑ Could such a product increase the demand for municipal compost facilities?

Activity

Exploring Decomposition in Water

Ask the group to identify an environment that was not talked about as a climatic region — underwater. Be sure to point out that biodegradable polymers are designed with specific disposal characteristics, including water solubility.

Discuss the advantages and disadvantages of manufacturing a product that is designed to degrade at sea or in a municipal wastewater system. Cite the Bio-Note example of the maritime ban on the disposal of plastics at sea.

Use the following demonstration to illustrate the behavior of certain biodegradable polymers in water.

1. Fill a container with water.
2. Place a biodegradable polymer material into the container.
3. Have the group watch for about five minutes. Then have them note the changes, especially how the material looks, feels and smells.
4. Repeat the activity using the workbook wrapper (or any water-resistant biodegradable polymer). See how long it takes for the product to become soft. Compare the time with the first product. You may wish to place a water-resistant sample into water ahead of time for comparison.

Processing

Based on this activity, have the group evaluate the issues and problems surrounding biodegradable polymers used aboard ships and in cities that dispose of some wastes into the oceans (which is illegal in many cases). Also discuss pros and cons of water disposal versus composting.

Materials

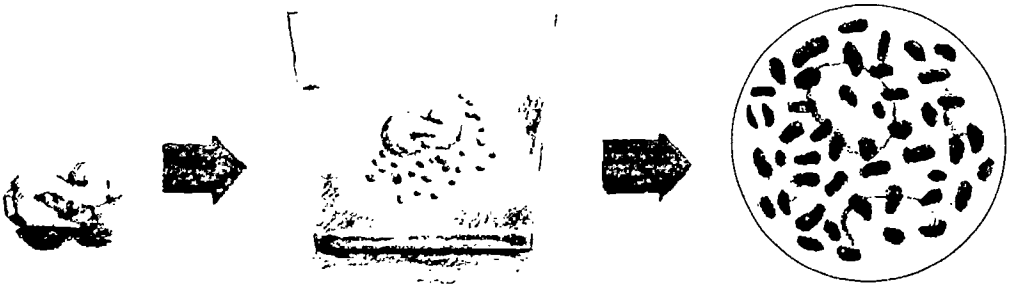
- ❑ one container
- ❑ water
- ❑ water-soluble biodegradable polymer
- ❑ water-resistant biodegradable polymer

Bio-Note

Biodegradable polymers can be designed to hold a liquid (like a spoon) for a time, or quickly come apart when in contact with a liquid (like a packing peanut). Either way, both can be decomposed by microbes in a composting situation.

Bio-Note

When water-soluble biodegradable polymers break apart, they leave behind a starch residue that is eventually decomposed by microbes.



Guiding Questions

1. After time, did the water-soluble product completely disappear or was there some evidence of its presence?
2. Is there a benefit to water-resistant biodegradable packaging?
3. Is there a benefit to a package that quickly comes apart in the water?
4. Can you see how water can aid in the decomposition of biodegradable polymers? Stress that water degradation is followed by the biological decomposition of the remaining product.

Going Beyond

Looking at Waste Water Disposal

(Recommended for older youth)

Continue the discussion by having the group consider the advantages of water-disposable products around the home. Discuss the implications for plastics that are discarded as litter.

You may wish to have the group conduct additional research on this topic by referring them to an illustrated article, "Sewage," in Volume 17 of the 1993 edition of the *World Book Encyclopedia* (World Book, Inc.). The article discusses urban and rural sewage treatment systems and includes illustrations of primary, secondary, and tertiary treatment methods.

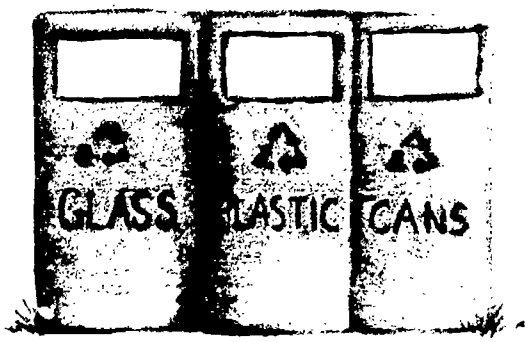
Bio-Note

The dumping of plastic waste into the sea by ships and stationary platforms is restricted by the Marine Pollution Treaty (MARPOL). The treaty, signed by a variety of countries, was written in response to the serious problems created by plastic waste at sea. Marine creatures often become entrapped and entangled in the waste or ingest (eat or swallow) it. Today's biodegradable polymers are a possible response to this and other environmental concerns.

7 Reasons to Recycle

Although biodegradable polymers are finding their way into the packaging arena, no one knows to what extent these natural polymers will replace their petroleum-based counterparts. For one reason, biodegradable polymers are designed to eventually break down when exposed to a microbially active environment (moisture alone is not enough). Biodegradable polymers also tend to be less durable than plastics, a desirable characteristic in some circumstances but not in others.

Plastics will exist as long as they continue to provide inexpensive and useful packaging. For this reason, attempts must be made to continue to reuse, reduce, and recycle traditional plastics. In order to divert plastics from municipal landfills and incinerators, plastic container manufacturers have joined together to classify and label existing plastics (see *Summary of Labeling*, Appendix IV). The idea is to provide plastic waste handlers, as well as the general public, with a system for identifying, separating and recycling the six basic types of plastic. Since the inception of this system, tons of plastic waste — most commonly PETE (polyethylene terephthalate) and HDPE (high density polyethylene) plastics — have been diverted annually from municipal landfills and incinerators.



Objectives

The students will learn about:

- the need to recycle plastics
- how plastics are identified for recycling
- the meaning of the recycling symbol, known as the Möbius Loop
- human behavior and recycling

Bio-Note

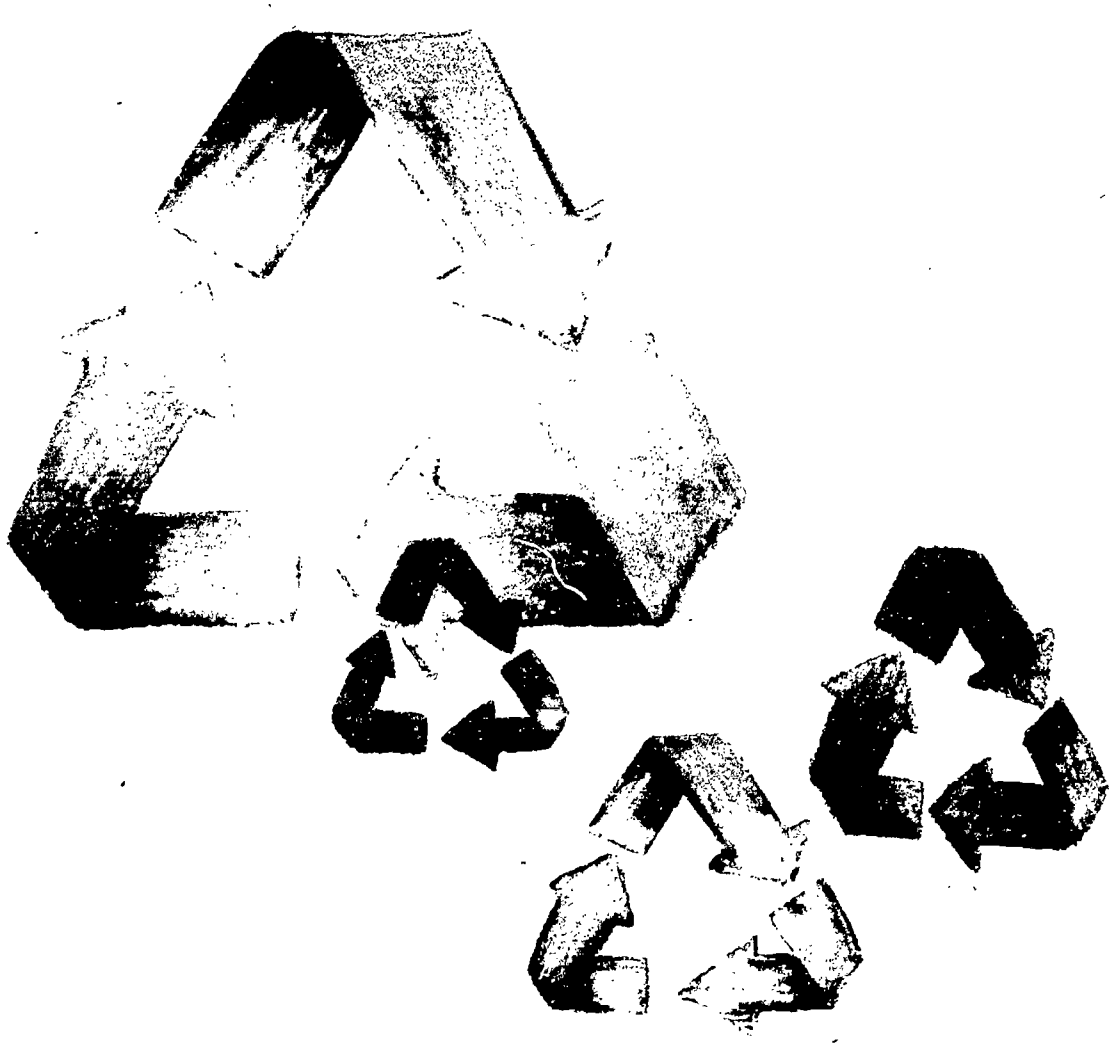
Biodegradable polymers are not intended to be recycled with other plastics. Rather, consumers are encouraged to separate biodegradable polymers and other organic materials from their normal household trash for composting or waste water disposal.

Discussion

Write the following quote on the chalkboard or flip chart.

"Whatever befalls the earth befalls the sons of the earth. Man did not weave the web of life, he is merely a strand in it. Whatever he does to the web, he does to himself." (Chief Seattle, 1854)

Discuss the meaning of this famous Native American's words. Is humanity part of the earth or do we just use the earth for our own ends? How do our actions come back to haunt us? Can we afford to abuse the life and resources of our earth?



Activity

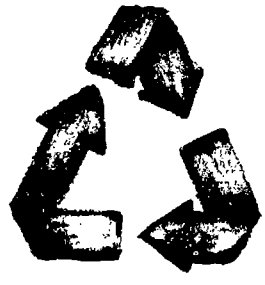
Understanding the Möbius Loop

This well-known symbol is used by recycling groups and industries throughout North America and Europe. If a product is stamped with the Möbius Loop, it is either produced from recycled materials (if the symbol is enclosed in a circle) or is recyclable (if there is no surrounding circle). The mark symbolizes the potentially never-ending use and reuse of materials. One arrow goes into another, just as materials get recycled into new products to be used over and over again. Help the group explore the meaning of the loop and why it reminds us to recycle.

1. Cut and distribute strips of paper that are 1 inch wide and 10-½ inches long.
2. Holding the ends of the strip, twist it once, then join the ends. Overlap the ends exactly one-quarter-inch and tape the ends in place on both sides (Figure A).
3. See if they can destroy the loop by cutting lengthwise down the center of the strip (Figure B). The group should end up with a single loop but twice as long as the original. Cut the loop again and end up with two loops.

Materials

- ❑ strips of paper, one-inch wide by 11 inches long
- ❑ ruler
- ❑ pencil
- ❑ tape



Processing

Have the group discuss how this experience relates to recycling. For example, every time you cut the loop you create a new product. Can the same be said for glass or plastic?

Activity

Exploring Plastic Package Labeling

Explain that plastic container manufacturers have joined together to classify and label existing plastics. This provides plastic waste handlers, as well as the general public, with a system for identifying, separating and recycling the seven basic types of plastics used in packaging. Note that within each type there is a range of plastic formulations.

1. Share a sample of plastic from each of the seven types of plastics used in packaging. Distribute *Summary of Labeling* (Appendix IV). Explain that because plastic packaging represents the largest use of plastics in the country, a special coding system was put in place. Ask if anyone is separating plastics at home using this system.
2. Have them examine each sample for the location of its code while making note of its unique properties.

Processing

Using a large piece of paper, have the group describe the characteristics of each plastic package, along with possible reasons for why it is used. For example, it keeps the product fresh, protects product from damage, prevents contamination, convenient to use and handle, easy to store, etc.

Materials

- ❑ samples of any of the seven types of plastics for packaging (with different Möbius loop numbers)

Activity

Brainstorming

Help the group think of different ways to reduce all wastes in the environment including plastics, such as reusing, reducing or recycling.

1. Ask what they can do differently right now to make things better. Lead them to consider practical solutions that everyone can use. Encourage them to think creatively as well as practically. For example, some great artists have made masterpieces out of trash.
2. Extend the activity by having them create their own masterpieces with discarded plastics. This would make a great display to alert the public about the need to recycle and reuse plastics.

Make a Point with Clay

1. Divide group in half, naming the groups "Throw-Aways" and "Recyclers." Give each person a piece of play clay. Tell them the clay represents a pliable petroleum polymer.
2. Have the group members divide their clay into three equal parts. Ask them to use one third of their clay to model a plastic jug. When they are finished, require the "Throw-Aways" to throw away their modeled jugs. Provide a clean trash can or trash bag so you can retrieve the clay later. Tell the "Recyclers" to work their molded jugs back into original lumps of clay.
3. Now ask the groups to model a plastic margarine tub with a third of their clay, again asking the "Throw-Aways" to discard their clay when they are finished and the "Recyclers" to rework theirs.
4. Finally, ask the group members to model a plastic cup with the remaining third of the clay. When the "Throw-Aways" dispose of their cups, they will be left with no more clay, while the "Recyclers" will have as much clay as they did at the start.

Processing

Ask the group members what they think should be done with the clay that was thrown away. Explain that once something enters our solid waste system, it is difficult to retrieve. However, separating and reusing is an example of recycling. By doing so, natural resources are saved for future generations and the solid waste system is relieved of unnecessary trash.

Materials

- ❑ play clay (see Ch. 2 for recipe)
- ❑ clean plastic bags to store clay

Packaging Scavenger Hunt

Prepare the group for Lesson 8 by having them go on a packaging scavenger hunt (see *Packaging Scavenger Hunt*, Appendix V). Challenge them to find a plastic package that they believe to be the most functional, creative, practical, or lightweight or the one that is the most excessively oversized in design. Ask that they clean and bring the item to the next meeting for further discussion.

Materials

- ❑ *Packaging Scavenger Hunt* Worksheet (Appendix V)

8 Natural Cycle Products and Packaging

Imagine a fast-food restaurant in the near future. Customers are served a hamburger in a package made from completely degradable materials. They eat soup with a biodegradable spoon and sip milk from a biodegradable cup with a biodegradable lid. When they're done, they throw it all in a bin with food scraps and food-soiled paper that will go to a local composting center. After six months, it will have been transformed into humus, a valuable source of soil organics. This may be sold to a gardener or farmer who will use it to replenish the soil. From this not-too-distant look into the future, one can see a balance between the life cycle of biodegradable products and the natural cycles from which they come.

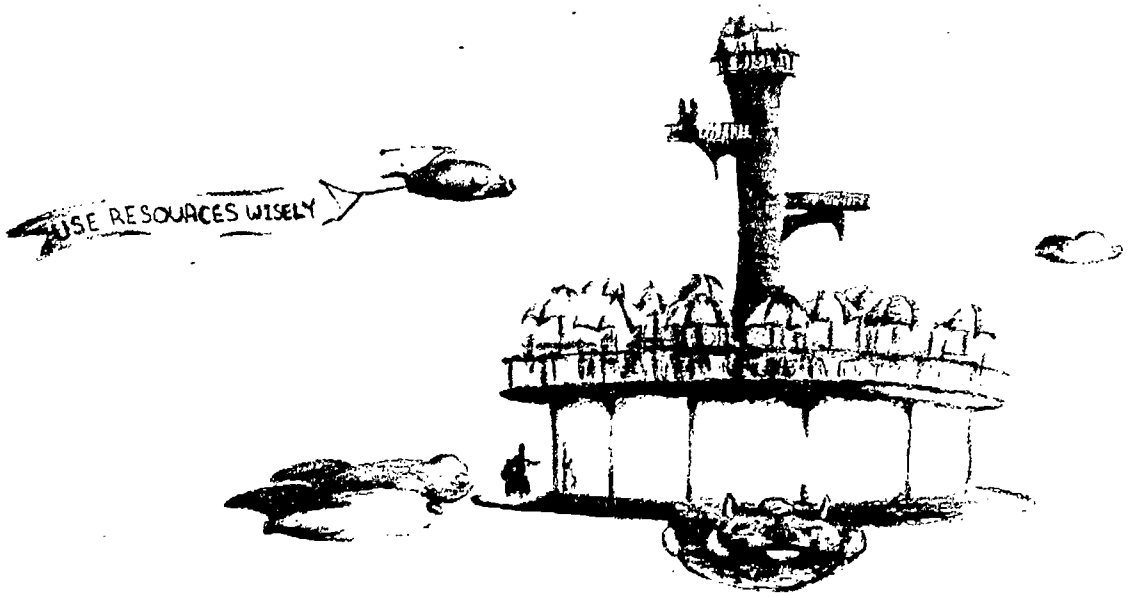
Objectives

The students will learn about:

- society's dependency on plastic packaging
- the variety of plastic packages in use today
- the role of product labeling in consumer choices
- challenges in marketing biodegradable products and packages

Discussion

Use this session to help the group focus on the range of possibilities for biodegradable polymers with products and packages. Read the opening scenario to set the stage. Encourage the group to keep this vision in mind as they perform the following activities.



Activity

Take a Closer Look at Packaging

Use this activity to have the group share what they discovered on their packaging scavenger hunt. Have each one describe what they experienced throughout the hunt.

1. Look at the unique packaging brought in by the group. Ask them to explain the purpose of the packaging they brought. List their ideas on the chalkboard, leading them to conclude that packaging is designed to protect the product, to protect the health of the consumer, to provide advertising, to promote purchasing, to provide convenience, and/or to make the product look larger.
2. Discuss handling options for the packaging.
3. Ask each person to examine one of the plastic packaging items brought in. Give them a copy of the worksheet, *Taking a Closer Look at Packaging* (Appendix VI) to use in working with the packaging. Allow them to work in teams to promote discussion.

Processing

Have the group map the life cycle of the plastic package they examined including natural cycle origins, the role of producers and consumers in its development, the steps in its manufacturing, marketing and distribution, and how it gets to the decomposers for return to the natural cycle.

Materials

- ❑ packaging found on the scavenger hunt
- ❑ chalk board or flip chart

Activity

Product Labeling

Use this activity to help the group understand the role of product labeling — especially ones that include claims about environmental or earth friendliness.

If possible, find products on the market that claim environmental or earth friendliness. Bring them to class.

Processing

Have the group analyze the product claims, then discuss the following questions.

Guiding Questions

- ❑ What should they assume if the product claims that its package is environmentally friendly but mentions nothing about biodegradability or how to dispose of it properly?
- ❑ What should they assume if the product mentions nothing about the characteristics of its plastic packaging?
- ❑ Do they see any advantages to labeling product packages with claims of biodegradability or compostability?

Materials

- ❑ products that claim environmental or earth friendliness

Activity

Green Marketing

All kinds of products and product packages are "going green." Companies have found that being sensitive to the environment is a selling point, and many are changing their product marketing to keep up with the trend.

1. Have the group break into small teams and brainstorm a product they would like to see packaged in a biodegradable plastic. Consider the limitations and characteristics when using such a polymer for packaging, as well as the climatic region where it will be used.
2. Ask them to design a product label that promotes the virtues of its package. Have advertisements available from magazines that make environmental claims about products and product packaging.
3. Have each team present their product package to the whole group in the form of a television commercial or product demonstration.

Materials

- ❑ paper
- ❑ scissors
- ❑ tape
- ❑ glue
- ❑ plastic scraps
- ❑ pens, markers, pencils

Going Beyond

Community Awareness

Inform the group that the final topic will deal with community awareness and public education. It will be their chance to share with others what they've learned.

Bio-Note

Remember, biodegradation occurs when the correct proportions of water, nutrients and microorganisms are present for the micro-organisms to consume the product. As the youth create their packages, ask: If a package is designed to decompose, what limits does that put on what the package can hold?

9 Package-Wise Public

The most important way to help people make informed decisions about what they buy, recycle, reuse or discard is to give them information. The more they hear about the decisions that need to be made, the more likely they will want to be part of the solution. All they need is a little encouragement and some information about new developments in technology, the need to separate and compost household biodegradable products, and how to reuse, reduce and recycle.

Objectives

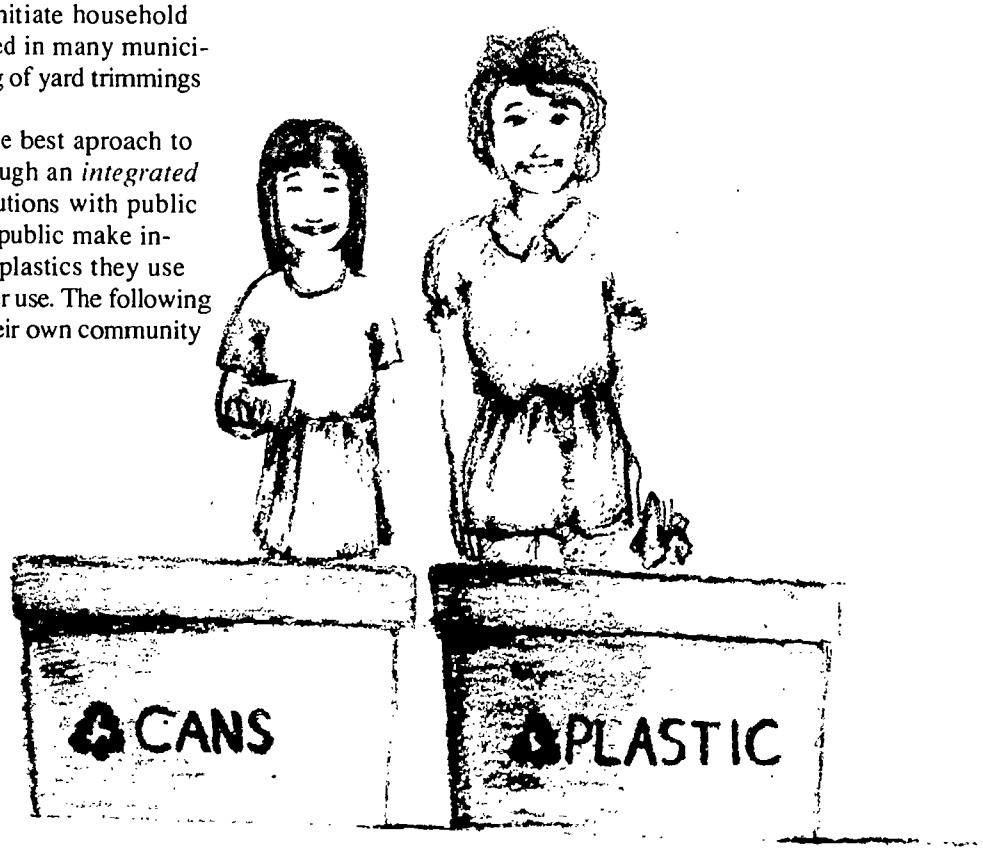
The students will learn about:

- applying knowledge from earlier sessions to real life situations
- educating others about biodegradable polymers
- helping others see the need for composting
- communicating with companies and public officials

Discussion

To accomplish this, a combined effort of education and community initiative is needed. Municipalities, for example, need to establish a recycling and composting infrastructure to make it easy, convenient and safe to pick up compostable household organics, just as existing programs work for recycling paper, glass, plastic and metals. It's easy to envision a bio-bin for household biodegradables for pick up. This separation will assure high quality input at the composting facility. If comm nity composting is not available, steps should be taken to initiate household composting. This has already occurred in many municipalities due to recent bans on disposing of yard trimmings in public landfills.

Help the group understand that the best aproach to solving solid waste problems is through an *integrated* initiative combining all types of solutions with public education. This includes helping the public make informed decisions about the types of plastics they use and how they are properly handled after use. The following activities will help the group design their own community education plan.



Activity

Make a Commitment

Explain it's now the group's turn to tell others about what they learned. Have them list things they can do in their home or community that will make a difference. At the end of the discussion, have each person list what he or she will do individually. Have them take their list home to share with parents and friends.

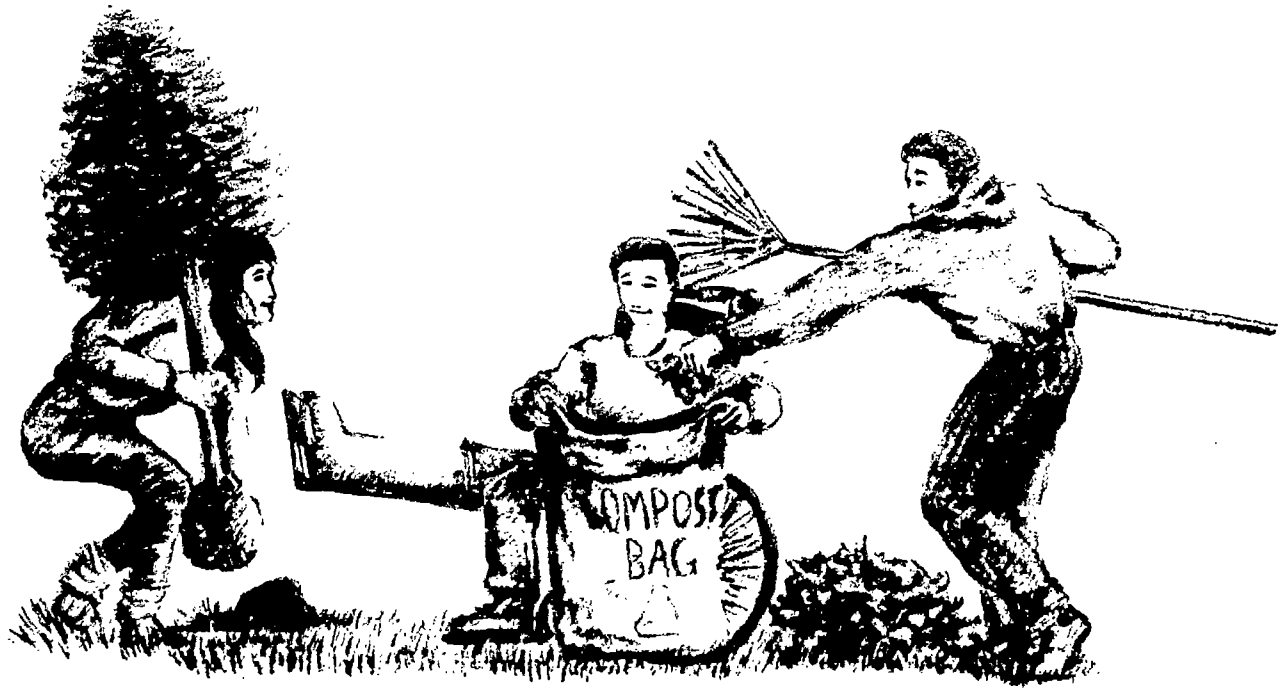
Materials

- ❑ paper
- ❑ pencil or pen

Activity

Have a Green Day

Turn the list they made into an invitation to their parents and friends to attend a Green Day celebration. Make this a time where others can see what the group has learned through exhibits, skits, and demonstrations. Encourage parents to become involved in doing something with the group to educate others about biodegradable polymers and promote reusing, reducing, and composting. Have the group come up with several ideas they could share with parents.



Activity

Write a Letter

Writing a letter is a good way to communicate concerns about the environment to other people. Have the group decide what issues they would like to address and whom to write. For example, write a letter to:

- ❑ the officers of a company congratulating them on practical, sensible packaging. Let them know that you appreciate what they are doing to help the earth.
- ❑ officials of your local, state or nation . government explaining your concerns about the lack of municipal recycling and composting facilities. Praise them for actions taken, state concerns in one or two sentences, offer possible solutions and ask for a response.
- ❑ the editor of a local newspaper expressing your feelings and opinions. Describe what steps community leaders might take toward increasing the awareness of the need for community composting. You may wish to include a photograph of your group doing something proactive to address these issues.

Photocopy and distribute the *Letter-Writing Tip Sheet* (Appendix VII).

Materials

- ❑ paper
- ❑ pencil or pen
- ❑ stamps
- ❑ envelopes

Activity

A Bulletin Board with a Message

1. Remind people that each person in the United States represents 1,000 pounds of waste discarded per year, of which 60 pounds is plastic packaging. Find a student in your group who weighs about 60 pounds.
2. Ask that group member to lie down on a length of butcher paper while other students draw around him/her with a marker. Have another student cut out the figure.
3. Attach the figure to a wall or bulletin board and then attach the student pledges stating what each will do to make the environment better.
4. Print a message at the top of the figure that reads "Cycle Back To Nature ... Use Resources Wisely."

Materials

- ❑ butcher paper
- ❑ plastic waste
- ❑ wall or bulletin board
- ❑ marker
- ❑ scissors

Going Beyond

Increase the Awareness

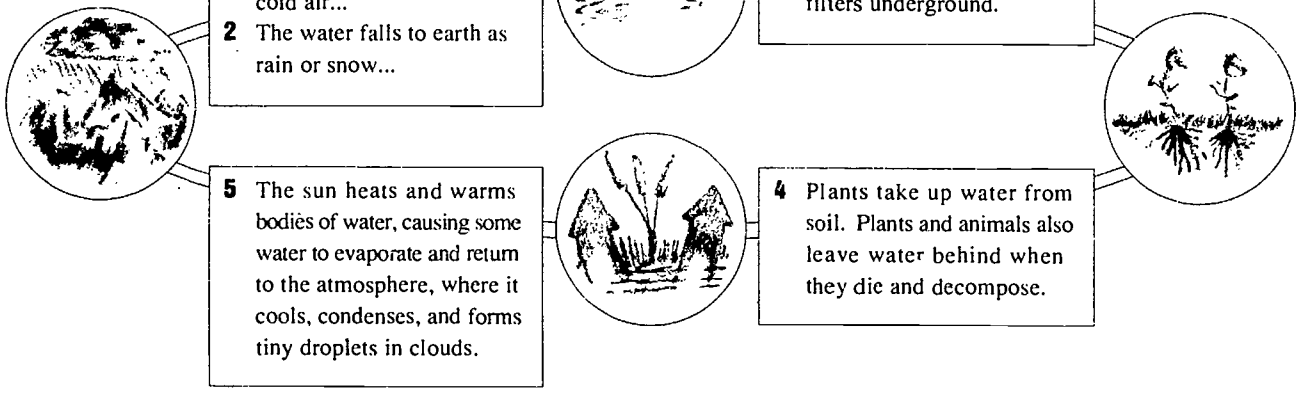
Based on the age of your group, there are a variety of things they can do to increase public awareness. This includes publishing a monthly newsletter of ideas, creating environmental issue posters, bumper stickers or tee shirts.

Other community activities include beach, river or lake clean-up days. Contact the Center for Marine Conservation, 1725 Desales St. NW, Washington, D.C., 20036 for a national events schedule.

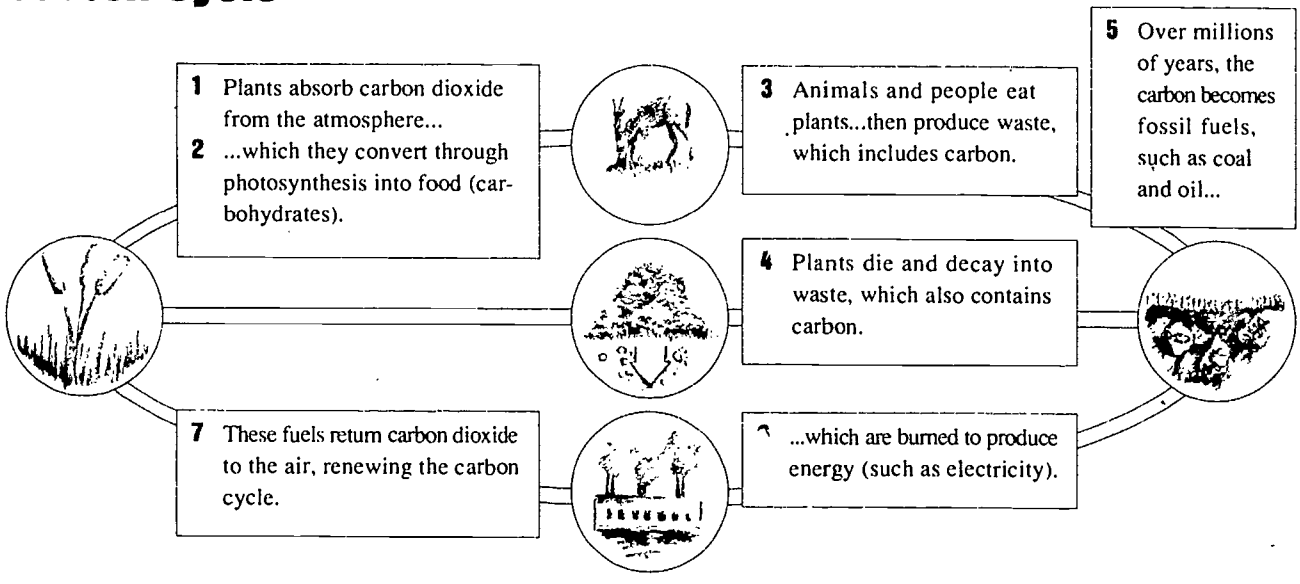
APPENDIX

I Earth Cycle Bio Sheet

Water Cycle



Carbon Cycle



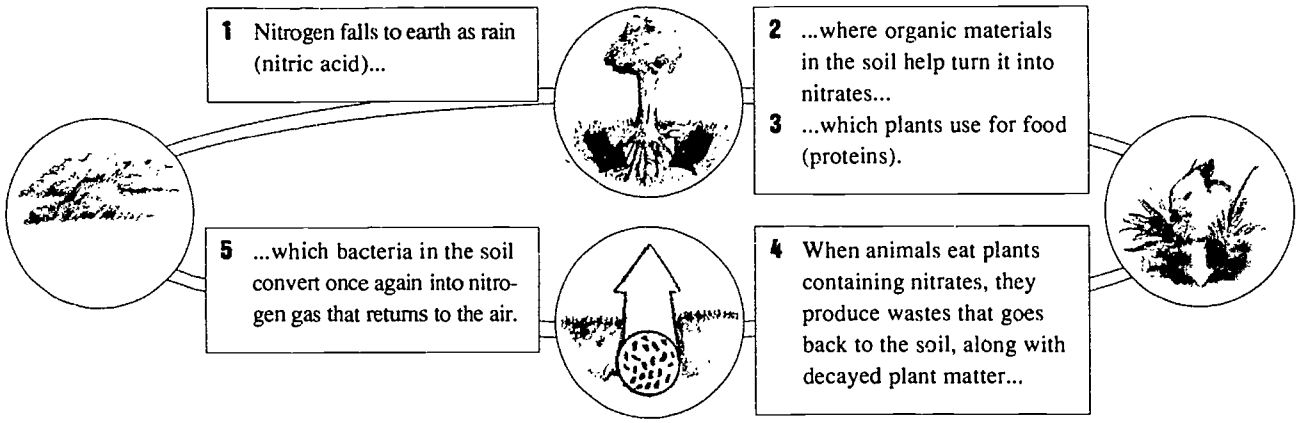
Appendix I Continued on page 57

APPENDIX

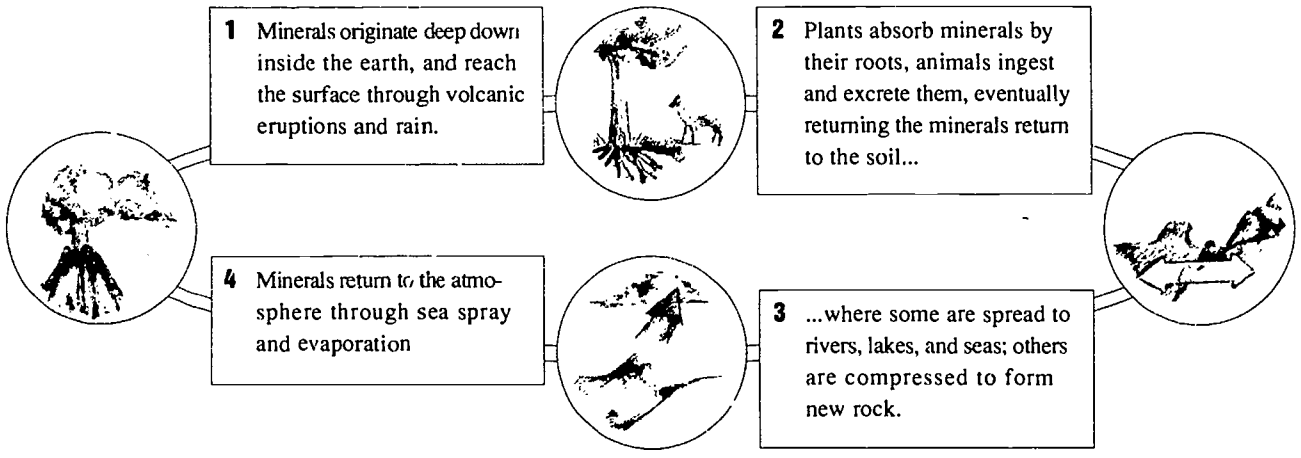
Earth Cycle Bio Sheet

Continued from page 57

Nitrogen Cycle

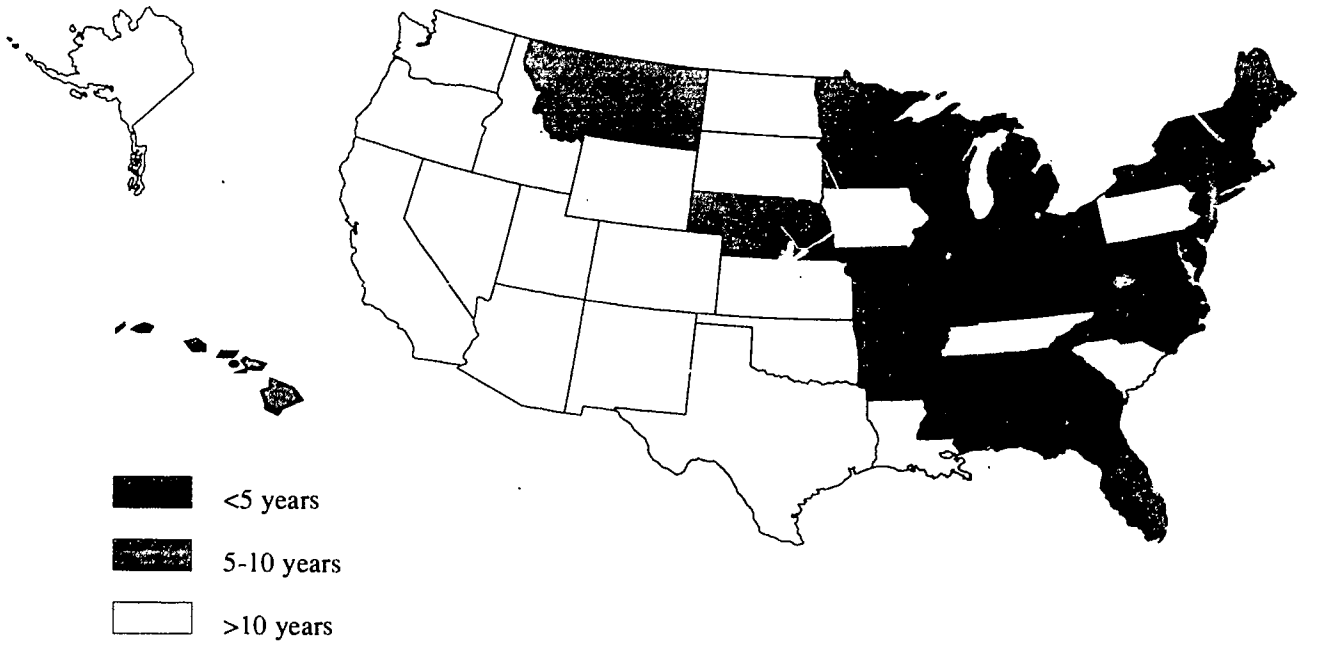


Mineral Cycle



APPENDIX

II Landfills Get Full



Answer the questions below.

1. Locate your state on the map. When will the landfills in your state be full? _____

2. List the states where landfills will be full in less than five years.

   _____

   _____

   _____

   In what region of the United States are all of these landfills located? _____

3. What do you think states will do when their landfills are full? Put a check in front of each action that a state might take.

   - ❑ Ship trash to another state.
   - ❑ Begin a recycling/composting program.
   - ❑ Open new landfills.
   - ❑ Teach people to make less trash.
   - ❑ Burn their trash.

National Solid Waste Management Association, 1992

APPENDIX

III Composting: Wastes to Resources*

Composting occurs naturally nearly everywhere! Leaves drop from trees. Grass clippings are left after mowing the lawn. Vegetable plants die at the end of the season. Over time, these organic materials break down or decompose. The rich, dark, soil-like material that results is called **humus,** also known as **compost.**

Tiny living organisms do much of the work of breaking down organic materials to form compost. These tiny workers are called microorganisms and include such things as bacteria and fungi. Animals, like worms and sowbugs, help microorganisms break down organic materials, too.

As microorganisms and soil animals turn organic materials into compost, they use the organic materials as food which provide nutrients for their growth and activity. Eventually, these nutrients are returned to the soil, to be used again by your garden plants. This is nature's way of recycling!

Why Composting?

With the method described below, you can help the composting cycle work even better and faster than it does in nature. The organic materials you put back into the environment through composting can be used by other living things. This way, instead of sending organic yard and garden trimmings to a landfill, they become valuable resources for your garden. However, it can be done both at home and in a municipal facility if one is available in your community.

* Written by Jean F. Bonhotal, Marianne E. Krasny
Cornell Cooperative Extension Publication

What to Compost?

Any plant material from your garden may be composted. You can also include other yard wastes such as leaves, weeds and dead flowers. Grass clippings can be composted but are really best left on the lawn; there they return nutrients to the soil directly.

You can also include other materials, such as sawdust, wood ash, coffe grounds, eggshells, fruit and vegetable scraps, and farm animal manure.

To get your compost pile to work best, include a good mix of *brown stuff* and *green stuff*. Other items you will need to add to your compost pile include soil, fertilizer and water.

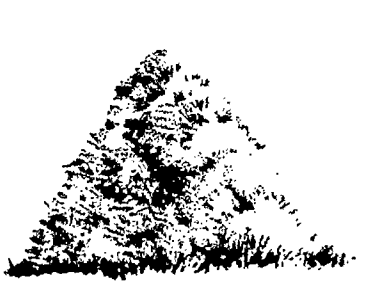
Brown Stuff	Green Stuff	Other Stuff
tree leaves (fall)	green leaves or plants	soil
corn stalks	weeds	fertilizer
straw	grass clippings	water
sawdust	coffee grounds	
wood chips	eggshells	
	cow or horse manure	

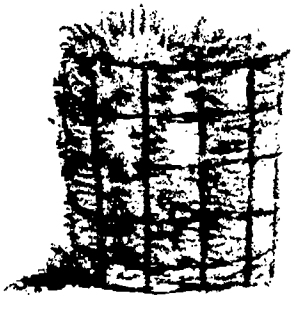
When composting at home, do not compost:

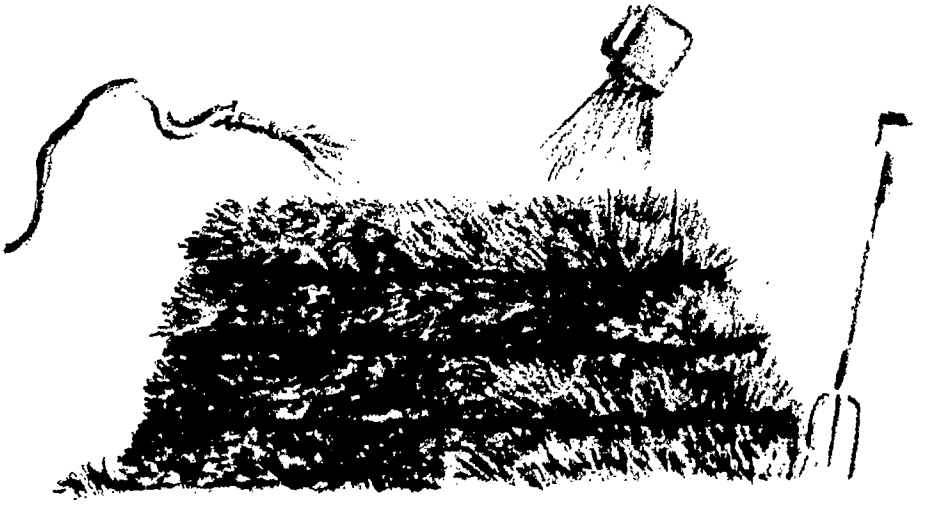
- ❑ Any part of black walnut trees (they release harmful toxins)
- ❑ Any meats, fish, bones, dairy products, breads, fatty or greasy foods or salad and cooking oils. These attract rodents and other unwanted pests.
- ❑ Dog and cat manures (they cause potential infection and disease problems)

Making a Home Compost Pile

1. Choose a place for your compost pile or bin. Place it on soil that drains well. Minimum size is 3'x3'x3'.
2. Place organic materials into the pile or bin layered as shown below. Chop or shred the materials if you want them to break down quickly.
3. Add water as needed; materials in the pile should be damp to the touch, like a wrung out sponge.
4. If you mix or turn your compost pile every week, it should be ready to use in one to two months. If you don't turn it, the compost should be ready in about six to twelve months. However, you may have an odor problem.
5. Your finished compost should look like dark crumbly soil mixed with small pieces or organic material. It should have a sweet, earthy smell.







APPENDIX

IV Summary of Labeling

Name	Used For	Recycling Process
1 Polyethylene Terephthalate (PET, often called "PETE")	Clear tops of 2-liter plastic soft drink bottles, food product bottles, disposable glasses	Cleaned and processed into flakes. Made into soft drink bottles, carpeting, and paint brushes. Shredded into fiber and used as the fluff in fiber-filled coats and sleeping bags.
2 High Density Polyethylene (HDPE)	Dark-colored bottoms of soft drink bottles, milk and water jugs, shampoo and detergent bottles, reusable drinking cups	Cleaned and processed into flakes. Made into milk and water jugs, trash cans, drainage pipes, and containers used to sort recyclables. Also turned into long, strong fibers used in bullet-proof vests.
3 Vinyl/ Polyvinyl Chloride (PVC)	Film for wrapping meat; bottles for edible oils, water and liquor; plumbing pipes; molded plastic furniture	All other recyclables are usually mixed together and ground up. The plastic bits are cleaned, heated, poured into large molds, and cooled. This mix is made into such items as plastic lumber, picnic tables, sand boxes, stadium seats, fencing, pallets, storage bins, park benches, car barriers, farm pens for poultry and pigs, seawalls, lobster traps, compost enclosures, golf course walkways, and playground equipment.
4 Low Density Polypropylene (LDPE)	Coffee can lids, 6-pack rings	
5 Polypropylene (PP)	Yogurt containers, screw tops, snap-on lids	
6 Polystyrene (PS)	Foam packaging for sandwiches, meat trays, disposable hot-drink cups, packing peanuts, egg cartons, insulation	
7 All Other Resins and Layered Materials (OTHER)	Squeeze bottles for some ketchups, sauces, syrups and jellies; molded office supplies; small food tubs	

Council of Plastic Packaging in the Environment, 1991

APPENDIX

V. Packaging Scavenger Hunt

How much aluminum, cardboard, cellophane, foil, paper, plastic, and polystyrene foam is used to package the foods you eat? Go to a grocery store or supermarket for a packaging scavenger hunt. See how many foods you can find with no wrapping, with one wrapping, with two wrappings, and with three or more wrappings. List the foods you find on the chart below.

Foods With No Wrapping

Example: apples

1. _____
2. _____
3. _____

Foods With One Wrapping

Example: bread
(in a paper or plastic bag)

1. _____
2. _____
3. _____

Foods With Two Wrappings

Example: cereal
(in a paper bag inside a cardboard box)

1. _____
2. _____
3. _____

Three or More Wrappings

Example: microwaveable meals
(on a plastic tray with a foil lid inside a cardboard box)

1. _____
2. _____
3. _____

APPENDIX

VI Taking a Closer Look at Packaging

Question:
What food product has its own natural packaging?

Answer:
A banana

Can you think of another?

_____

Question:
What food product comes in packaging you can eat?

Answer:
An ice cream cone

Can you think of another?

_____

Choose a product that is packaged. Look closely at the packaging. Then answer the questions below:

1. What is the name of the product you chose?
2. What does the packaging do for the product? Put a check beside each statement that is true about your product.
   - ❑ The packaging protects the product.
   - ❑ The packaging protects the health of the consumer.
   - ❑ The packaging provides advertising.
   - ❑ The packaging promotes purchasing.
   - ❑ The packaging provides convenience.
   - ❑ The packaging makes the product look larger.
3. Is the packaging made from recycled materials? _____
4. Is the packaging recyclable or will it have to be thrown away? _____
5. Do you think this product has too much packaging? Why or why not? _____
6. If you were asked to design a better package for this product, what would you suggest? _____

Draw it on the back of this page.

APPENDIX

VII Letter Writing Tip Sheet

When writing to the president of the United States, address your letter and envelope as follows:

President (Name)

The White House

1600 Pennsylvania Avenue

Washington, D.C. 20500

When writing to a United States senator, address your letter and envelope as follows:

The Honorable (senator's name)

U.S. Senate

Washington, D.C. 20500

When writing to a member of the U.S. House of Representatives, address your letter and envelope as follows:

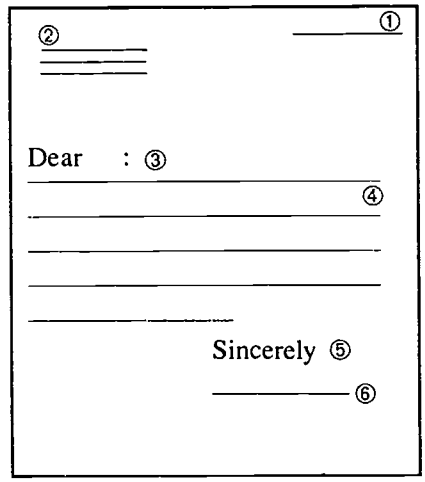
The Honorable (member's name)

U.S. House of Representatives

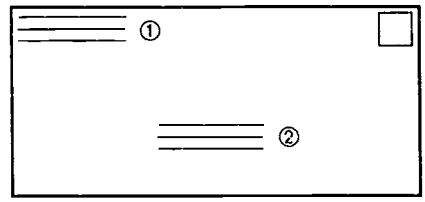
Washington, D.C. 20500

If you do not know who your United States senators or representatives are, you can find their names listed at your local library.

This is the correct form for writing and addressing a business letter.



1. date
2. heading or inside address
3. greeting
4. body
5. closing
6. signature



1. return address — your name, street address, city, state, and zip
2. address of the person or organization to whom you are writing

Acknowledgments

National 4-H Council wishes to thank the following organizations for participating on the Biodegradable Polymer Advisory Technical Committee and for contributing to the manuscript development and review process:

ECOCHEM
Michael Fisher
William Hendrix

J.D.M. Unlimited
John Moore

National Corn Growers Association
Tim Draeger

Novon Products, Div. of Warner-Lambert Co.
John Sherwin
Steve Mojo
David Brooks

University of Hawaii
Jim Hollyer

U.S. Army Natick Research, Development & Engineering Center

USDA Economic Research Service
Douglas Beach

USDA/Cooperative States Research Service
Daniel Kugler
Chauncey Ching
Davis Clements

USDA 4-H
Greg Crosby

ZENECA Bio Products/ZENECA, Inc.
William Luzier

We'd like to thank the following organizations and university-based cooperative extension services for reviewing the manuscript at various stages:

American Plastics Council
Paula Cox

Cargill Research
Robert Buehler
Patrick Gruber

The Composting Council

Household Hazardous Waste Project
Sarah Dewey

Novon, Div. of Warner-Lambert Co.
Rhonda Brooks
Ken Tracy

Procter & Gamble
Margaret Conditt
Tom Rattray
Bob Campbell

U.S. Environmental Protection Agency
Tracy Bone

ZENECA Bio Products/ ZENECA Inc.
Julie Saad

Michigan State University
Janet Olsen

Montana State University
Michael Carvey
David Streufert

New Mexico State University
Roy Vaughan

North Carolina State University
Rhonda Sherman
Edward Maxa

North Dakota University
Annette Bach

Oregon State University
Virginia Thompson

Purdue University
Susan Edinger

Rutgers College
Laura Bovitz

Texas A&M University
Ron Howard Jr.

University of California
Richard Ponzio

University of Hawaii-Manoa
Gary Gerhard
Deborah Ward
Bambi Torres
Susan Yee
Ike Ikawa
Steve Nagano

University of Illinois
Ann Rund

University of Maryland
Judith Williamson

University of Missouri-Lincoln
Patsy Bell Hobson

University of New Hampshire
Richard Bonneville

University of Rhode Island
Barbara Sullivan
Ernest Morreira

University of Tennessee
Oliver Cook

University of Virgin Islands
Joseph Fulgence

University of Wisconsin
Bonnie Herrmann

University of Wyoming
Beth Kaplan
Lorraine Forcina

Utah State University
Michael Allred

West Virginia University
Winthrop Merriam, Jr.

Finally, we extend special thanks to the following 4-H organizations for pilot-testing the curriculum:

Montana

Hawaii

Missouri

Nevada

Oregon

National 4-H Council's programs are open to all citizens without regard to race, color, sex, handicap, religion, age, or national origin. Mention or display of a trademark, proprietary product, or firm in text or figures does not constitute an endorsement by the National 4-H Council and does not imply approval to the exclusion of other suitable products or firms.

This material is based upon work supported by the Cooperative State Research Service, U.S. Department of Agriculture, under Grant/ Cooperative Agreement Number: 91-COOP-6107.

Any opinions, findings, conclusions, or recommendations expressed in this publication are those of author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.

Printed on Recycled Paper

ES 0001-01/94-5000